FLUKE 88

Automotive Meter

Service Manual

FLUKE®

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Automotive Meter

Service Manual

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Fluke Corporation
P.O. Box 9090
Everett WA 98206-9090

Fluke Europe B.V.
P.O. Box 1186
5602 B.D.
Eindhoven
The Netherlands

MULTIMETER SAFETY

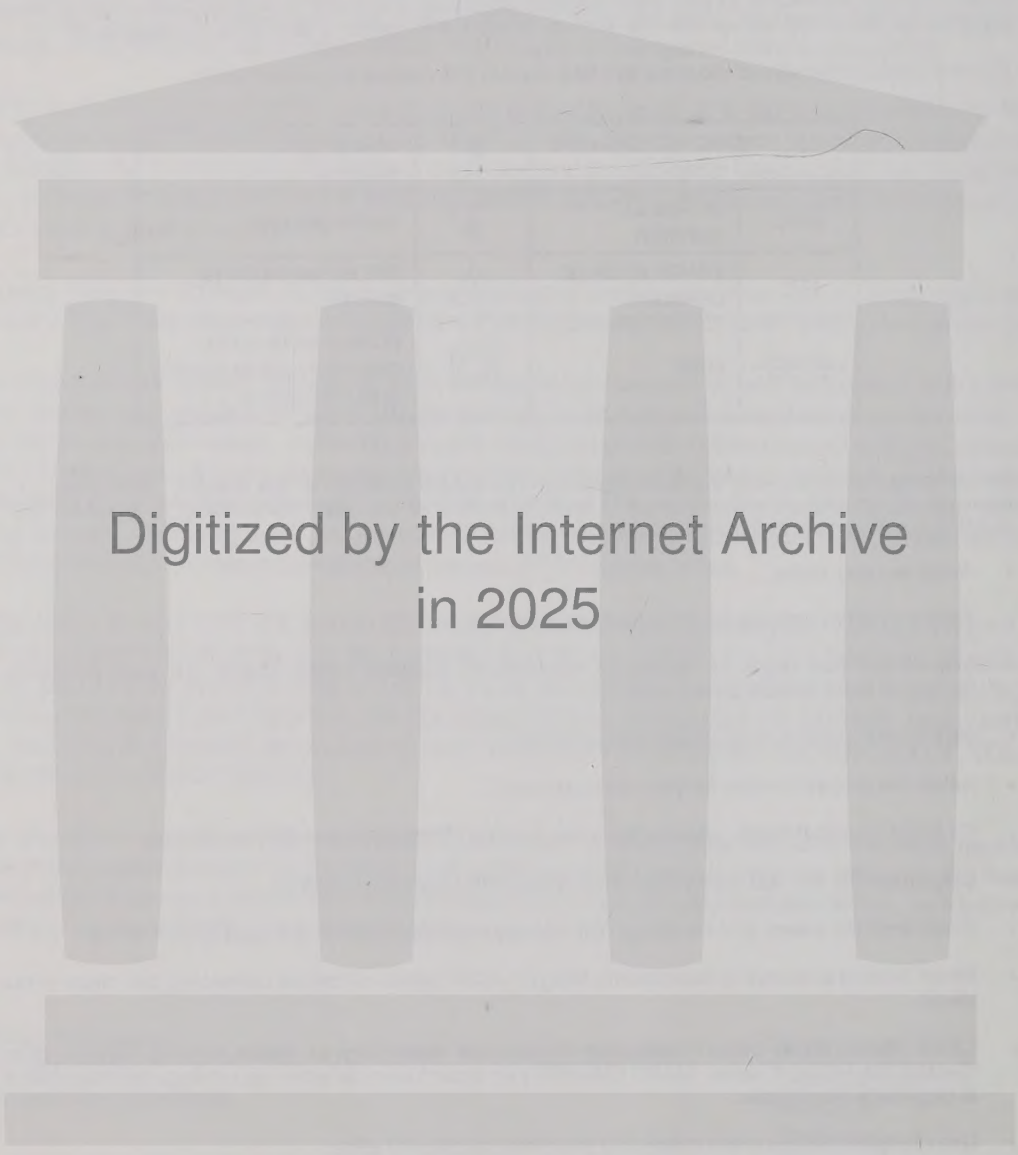
The Fluke 88 Multimeter has been designed and tested according to IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus. This manual contains information and warnings which must be followed to ensure safe operation and retain the meter in safe condition. Use of this equipment in a manner not specified herein may impair the protection provided by the equipment.

Some common international electrical symbols used in this manual are shown below.

~	AC – ALTERNATING CURRENT	ϟ	DANGEROUS VOTLAGE
⎓	DC – DIRECT CURRENT	⏚	EARTH GROUND
≂	EITHER AC OR DC CURRENT	⚠	SEE EXPLANATION IN MANUAL
⎯▭⎯	FUSE	⧈	DOUBLE INSULATION FOR PROTECTION AGAINST ELECTRIC SHOCK

Before using the meter, read the following safety information carefully. In this manual, "WARNING," is reserved for conditions and actions that pose hazard(s) to the user; "CAUTION," is reserved for conditions and actions that may damage your meter.

- Avoid working alone.
- Follow all safety procedures for equipment being tested.
- Inspect the test leads for damaged insulation or exposed metal. Check test lead continuity. Damaged leads should be replaced.
- Be sure the meter is in good operating condition.
- Select the proper function for your measurement.
- To avoid electrical shock, use caution when working above 60V dc or 30V ac RMS.
- Disconnect the live test lead before disconnecting the common test lead.
- Disconnect the power and discharge high-voltage capacitors before testing in Ω and →|–)))).
- When making a current measurement, turn the circuit power off before connecting the meter in the circuit.
- Check meter fuses before measuring transformer secondary or motor winding current. (See "Testing the Fuse(s)" under MAINTENANCE.) An open fuse may allow high voltage build-up, which is potentially hazardous.
- Use clamp-on probes when measuring circuits exceeding 10 amps.
- When servicing the meter, use only the replacement parts specified.



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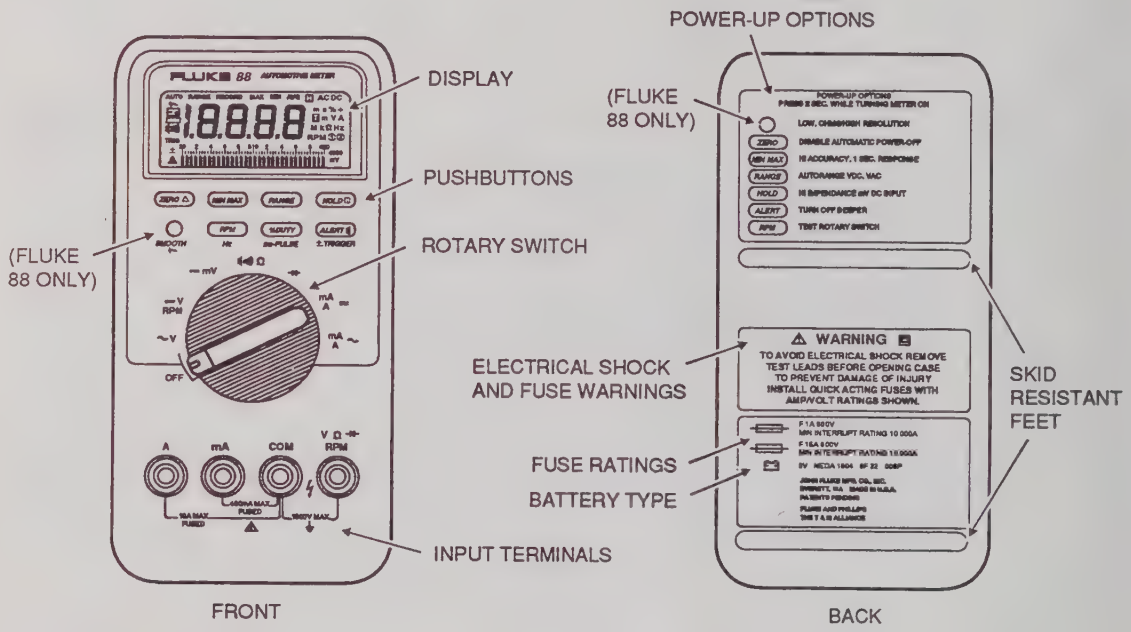

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Section 1
Introduction and Specifications

1-1. INTRODUCTION

This Service Manual provides information necessary to service the Fluke 86 and 88 Automotive Meters. This information includes the following:

- Specifications
- Theory of operation
- Calibration routines
- Performance testing and troubleshooting procedures
- Replacement parts lists
- Schematic diagrams
- Backdating Information

A meter under warranty will be promptly repaired or replaced (at Fluke's option) and returned at no charge. See the registration card for warranty terms. If the warranty has lapsed, the meter will be repaired and returned for a fixed fee. Contact the nearest Service Center for information and prices. A list of Service Centers is at the end of Section 4 of this manual.

1-2. ORGANIZATION OF THE SERVICE MANUAL

The Service Manual has six sections.

SECTION 1. INTRODUCTION AND SPECIFICATIONS

Section 1 describes the Service Manual and explains conventions used to describe the meter's circuitry. A complete set of specifications appears at the end of this section.

SECTION 2. THEORY OF OPERATION

Section 2 treats the meter's circuitry as functional blocks, with a description of each block's role in overall operation. A detailed circuit description is then given for each block. These descriptions explore operation to the component level and support the troubleshooting and repair procedures in Section 3.

SECTION 3. MAINTENANCE

Section 3 provides complete maintenance information, detailed troubleshooting and repair procedures to the component level, and performance tests. Troubleshooting and repair procedures rely on the theory of operation in Section 2 and the schematic diagrams in Section 5.

SECTION 4. LIST OF REPLACEABLE PARTS

Section 4 provides parts lists for all assemblies and information on how to order parts.

SECTION 5. SCHEMATICS AND SIGNAL FLOW DIAGRAMS

Section 5 provides schematic and signal flow diagrams. A list of mnemonic definitions is included to aid in identifying signal name abbreviations.

1-3. CONVENTIONS

The following conventions are used in this manual:

- Instrument Reference

  The term "Meter" is used when discussing common features of the Fluke 86 and 88 meters, and the model number is not used. Where features differ between models, these differences are identified as belonging to one model or the other (i.e., the Fluke 86 or Fluke 88).

- Printed Circuit Assembly

  The term "pca" is used to mean a printed circuit board and its attached parts.

- Signal Logic Polarity

  Signal names followed by a minus sign (-) are active (or asserted) low. Signals not so marked are active high.

- Circuit Nodes

  Individual pins or connections on a component are specified by a dash (-) following the component reference designator. For example, pin 19 of U30 would be U30-19.

- User Notation

  Pushbuttons, positions on the rotary switch, input terminals, and the display are genrally shown in the manual as they appear on the Meter.

  Mnemonics used in the text that describe Meter circuitry are the same as those used on the schematic diagrams in Section 5.

1-4. SPECIFICATIONS

Specifications for the Fluke 86 and 88 follow.

Accuracy is specified at 18° C to 28° C (64° F to 82° F) with relative humidity up to 90%, for a period of one year after calibration. AC Conversions are ac-coupled, average responding, and calibrated to the RMS value of a sine wave input.

NOTE

The Fluke 88 has a Lo-Ohms/High Resolution power-up option. In the Lo-Ohms/High Resolution mode, the resolution is ten times that in the following specifications. To enter the Lo-Ohms/High Resolution mode, press and hold down the SMOOTH button, while turning the rotary switch to a function setting.

1-5. Summary of Accuracy Specifications

The table below provides a summary of the accuracy specifications for basic Meter functions.

FUNCTION	BASIC ACCURACY (± % of Reading)	
	FLUKE 86	FLUKE 88
Volts AC ~V	1.5%	1.5%
Volts DC ⎓ V	0.3%	0.15%
Resistance Ω	0.4%	0.2%
Milliamps/Amps DC mA A⎓	1.0%	0.8%
Frequency Hz	0.01%	0.01%

1-6. Complete Accuracy Specifications

The complete Meter specifications follow. In the complete specifications, accuracy is given as:

±([% of Reading] + [Number of Least Significant Digits])

Input Terminals Limits

ROTARY SWITCH FUNCTION	RED LEAD	MIN DISPLAY READING FLUKE 86	MIN DISPLAY READING FLUKE 88	MAX DISPLAY READING	MAXIMUM INPUT***
~V	V Ω ⊣◀	0.1 mV	0.01 mV	1000V	1000V
⎓ V RPM	RPM	0.001V	0.0001V	1000V	1000V
⎓ mV	V Ω ⊣◀	0.1 mV	0.01 mV	400.0 mV	1000V
))) Ω	V Ω ⊣◀	0.1Ω	0.01Ω (Lo-Ohms)	400.0 MΩ	1000V*
⊣◀	V Ω ⊣◀	0.001V	0.0001V	3.000V	1000V*
mA A~	A mA	1 mA 0.01 mA	0.1 mA 0.001 mA	20.00A** 400.0 mA	10A/600V** 400 mA/600V
mA A ⎓	A mA	1 mA 0.01 mA	0.1 mA 0.001	20.00A** 400.0 mA	10A/600V** 400 mA/600V

* For circuits < 0.3A short circuit, 660V for high energy circuits.
** 10A continuous, 20A for 30 seconds maximum.
*** 10^7 V-Hz maximum.

Volts AC ~V

RANGE	RESOLUTION	ACCURACY * 45 Hz to 1 kHz	ACCURACY * 1 kHz to 5 kHz
400.0 mV	0.1 mV	±(1.5%+10)	±(1.9%+10)
4.000V	0.001V	±(1.5%+5)	±(1.9%+5)
40.00V	0.01V	±(1.5%+5)	±(1.9%+5)
400.0V	0.1V	±(1.5%+5)	±(1.9%+5)
1000V	1V	±(2.5%+5)	±(2.5%+5)

* Below a reading of 200 counts, add 10 digits.

Volts DC ⎓ V

RANGE	RESOLUTION	ACCURACY FLUKE 86	ACCURACY FLUKE 88
4.000V	0.001V	±(0.3%+2)	±(0.15%+2)
40.00V	0.01V	±(0.3%+2)	±(0.15%+2)
400.0V	0.1V	±(0.3%+2)	±(0.15%+2)
1000V	1V	±(0.5%+1)	±(0.3%+2)

Millivolts DC ⎓ mV

RANGE	RESOLUTION	ACCURACY	
		FLUKE 86	FLUKE 88
400.0 mV	0.1 mV	±(0.3%+2)	±(0.15%+2)

Resistance (Ω)

RANGE	RESOLUTION	ACCURACY	
		FLUKE 86	FLUKE 88
400.0Ω	0.1Ω*	±(0.4%+2)	±(0.2%+2)
4.000 kΩ	0.001 kΩ	±(0.4%+2)	±(0.2%+2)
40.00 kΩ	0.01 kΩ	±(0.4%+2)	±(0.2%+2)
400.0 kΩ	0.1 kΩ	±(0.4%+2)	±(0.2%+2)
4.000 MΩ	0.001 MΩ	±(0.4%+2)	±(0.2%+2)
40.00 MΩ	0.01 MΩ	±(1%+3)	±(1%+3)
400.0 MΩ†	0.1 MΩ	±(1%+20)	±(1%+20)

* In Fluke 88 Lo-Ohms/High Resolution Mode, increases to 0.01Ω.
† This range will not be entered by Autorange. It must be selected manually.

Diode Test →|←

RANGE	RESOLUTION	ACCURACY
3.000V	0.001V	±(2%+2)

mA/A DC mA ⎓ A ⎓

RANGE	RESOLUTION	ACCURACY		BURDEN VOLTAGE (typical)
		FLUKE 86	FLUKE 88	
40.00 mA	0.01 mA	±(1.0%+2)	±(0.8%+2)	2.3 mV/mA
400.0 mA	0.1 mA	±(1.0%+2)	±(0.8%+2)	2.3 mV/mA
4000 mA	1 mA	±(1.0%+2)	±(0.8%+2)	0.03 V/A
10.00 A*	0.01A	±(1.5%+2)	±(1.3%+2)	0.03 V/A

* 10A continuous, 20A for 30 seconds maximum.

mA/A AC (45 Hz to 2 kHz) mA A~

RANGE	RESOLUTION	ACCURACY **	BURDEN VOLTAGE (typical)
40.00 mA	0.01 mA	±(3%+10)	2.3 mV/mA
400.0 mA	0.1 mA	±(3%+5)	2.3 mV/mA
4000 mA	1 mA	±(1.5%+5)	0.03V/A
10.0A*	0.01A	±(1.5%+5)	0.03VA

* 10A continuous, 20A for 30 seconds maximum.
** Below a reading of 200 counts, add 10 digits.

Frequency, RPM, Duty Cycle, and Pulse Width

FUNCTION	RANGE	RESOLUTION	ACCURACY	PULSE WIDTH RANGE (ms)#	RESOLUTION (ms)
Frequency*	199.99	0.01 Hz	±(0.01% +1)	1999.9	0.1
(0.5 Hz to	1999.9	0.1 Hz	±(0.01% +1)	5.00	0.01
200 kHz,	19.999 kHz	0.001 kHz	±(0.01% +1)	0.500	0.001
Pulse Width	199.99 kHz	0.01 kHz	±(0.01% +1)	0.0500	0.0001
>2 µs)	>200 kHz	0.1 kHz	Unspecified		
RPM 1	30-9,000	1 RPM	± 2 RPM		
RPM 2	60-12,000	1 RPM	± 2 RPM		
%Duty Cycle†	0.0-99.9% (0.5 Hz to 200 kHz, Pulse Width > 2 µs)				
Pulse Width†	0.002-1999.9 ms (4 Hz to 200 kHz, Pulse Width > 2 µs)				

\# Pulse Width range is determined by the frequency of the signal.
* Frequency measurements can be made on voltage or current inputs. The current inputs are always dc-coupled.
† For rise times < 1 µs. Duty Cycle accuracy: within ±(0.2% per kHz + 0.1%). Pulse Width accuracy: ±(0.002 ms + 3 digits).

Counter Sensitivity and Trigger Level

INPUT RANGE*	MINIMUM SENSITIVITY @ 0.5 Hz-200 kHz (RMS SINEWAVE)	APPROXIMATE TRIGGER LEVEL (DC VOLTAGE FUNCTION)
400 mV dc	70 mV (to 400 Hz)	40 mV
400 mV ac	150 mV	–
4V	0.7V	1.7V
40V	7V	4V
400V	70V (≤140 kHz)	40V
1000V	700V (≤14 kHz)	400V

* Maximum input for specified accuracy = 10 x Range or 1000V.

Common and Normal Mode Rejection Ratio

FUNCTION	OVERLOAD PROTECTION+	INPUT IMPEDANCE (nominal)	COMMON MODE REJECTION RATIO (1 kΩ unbalance)	NORMAL MODE REJECTION RATIO
⎓ V	1000V rms	10 MΩ, <100 pF	>120 dB at dc, 50 Hz, or 60 Hz	>60 dB at 50 Hz or 60 Hz
⎓ mV	1000V rms	10 MΩ, <100 pF	>120 dB at dc, 50 Hz, or 60 Hz	>60 dB at 50 Hz or 60 Hz
~V	1000V rms	10 MΩ, <100 pF (ac-coupled)	>60 dB, dc to 60 Hz	

Ω		OPEN CIRCUIT TEST VOLTAGE	FULL SCALE VOLTAGE		SHORT CIRCUIT CURRENT
			To 4.0 MΩ	40 MΩ or nS	
	1000V rms++	<1.3V dc	<450 mV dc	<1.3V dc	<500 μA
Diode Test	1000V rms++	<3.9V dc	3.000V dc		1.0 mA typical

\+ 10^7 V-Hz max.
++ For circuits < 0.3A short circuit, 660V for high energy circuits.

MIN MAX Recording

NOMINAL RESPONSE	ACCURACY
100 ms to 80%	Specified accuracy ± 12 digits for changes > 200 ms in duration
1 sec	Same as specified accuracy for changes > 2 seconds in duration

General

Maximum Voltage between any Terminal and Earth Ground		
	1000V.	
Fuse Protection		
mA	1A 600V FAST FUSE	
A	15A 600V FAST FUSE	
Display (LCD)		
Digital	Counts:	4,000 19,999 in Fluke 88 High Resolution, 4 1/2-digit Mode only.
	Update Rate:	1/sec in Fluke 88 High Resolution, 4 1/2-digit Mode only. 3/sec in RPM, Frequency, %Duty Cycle, and Pulse Width. 4/sec in all other functions and ranges.
Analog	2 x 32 Segments Updates Rate:	40/sec
Frequency and RPM	Counts: Update Rate:	19,999 3/sec @ > 10 Hz
Backlight (Fluke 88 Only)	Backlight turns on for 68 seconds, then turns off automatically if not turned off by user.	
Meter Operating Temperature	-20°C to 55°C (-4°C to 131°F)	
Meter Storage Temperature	-40°C to 60°C (-40°C to 140°F)	
Temperature Coefficient	0.05 x (Specified Accuracy)/°C (<18°C or >28°C; <64°F or >82°F)	
Relative Humidity	0% to 90% (0°C to 35°C; 32°F to 95°F) 0% to 70% (35°C to 55°C; 95°F to 131°F)	
Inductive Pickup		
Input	Magnetic Field from Spark Plug	
Output	Pulse to Trigger Fluke 86 and Fluke 88.	
Maximum RPM	12,000 (RPM 2)	
Battery Type	9V, NEDA 1604 or 6F22 or 006P	
Battery Life	500 hrs typical with alkaline	
Shock, Vibration	PER MIL-T-28800 for a Class 2 Instrument	

Size (HxWxL)		
	Meter Only	1.25 in x 3.41 in x 7.35 in (3.1 cm x 8.6 cm x 18.6 cm)
	With Holster & Flex-Stand	2.06 in x 3.86 in x 7.93 in (5.2 cm x 9.8 cm x 20.1 cm)
Weight		
	Meter Only	12.5 oz (355g)
	With Holster & Flex-Stand:	22.0 oz (624g)
Safety		
	Meter	Designed to Protection Class II per IEC 348, CSA C22.2 No. 231, ISA-DS82, and UL1244.
	Pickup	Specified for spark-plug wire use only.

Section 2
Theory of Operation

2-1. INTRODUCTION

Section 2 provides the theory of operation for the Fluke 86 and Fluke 88. Unless otherwise specified, the descriptions apply to both instruments.

An overview of circuit operation is presented in the form of functional block descriptions. Detailed circuit descriptions cover the major circuit functions in more detail. Schematic diagrams are in Section 5.

2-2. FUNCTIONAL BLOCK DESCRIPTION

Figure 2-1 is a block diagram of the Fluke 86 and Fluke 88 Automotive Meters. The Meter is partitioned into analog and digital sections. The integrated meter chip (U4) performs both analog and digital functions.

The analog section of U4 contains the analog-to-digital (a/d) converter, active filter, ac converter, frequency comparator, analog signal routing, range switching, and power supply functions.

The digital logic portion of U4 provides the state machine for synchronous a/d converter control and the 16-bit counter used for a/d converter counts and frequency measurements. Also, the digital logic section contains bus and interrupt control circuits (to facilitate the microcomputer interface) and registers for analog switch drive.

The microcomputer section of U4 executes software functions, formats data for the display, drives the display, and controls most analog and digital logic functions. The pushbuttons initiate various operating modes for the microcomputer. Output from the microcomputer can be presented visually on the liquid crystal display (LCD) and audibly by the beeper.

2-3. DETAILED CIRCUIT DESCRIPTION

Each of the functional blocks in Figure 2-1 is discussed in greater detail in the following paragraphs. Refer to the schematic diagrams in Section 5 for details not shown in the figures in this section.

2-4. Input Overload Protection

Overload protection for the V Ω ⊣⊢ input is provided by a network of two metal-oxide varistors (RV1 and RV2), three current-limiting resistors (R1, R2, and RT1), and spark gap E1. The 1-kΩ, 2W fusible resistor R1 opens when an extremely high energy signal is present. Thermistor RT1 rises to a high impedance during a sustained voltage overload in the mV dc, ohms, or diode test functions. A voltage clamp network is formed by transistors Q1, Q2, and Q6, diodes CR7 and CR8, and resistor R58. During ohms and diode test overloads, this clamp circuit limits the overload current to U4 to 10 mA. Power supply regulation and system operation is maintained during any of these overloads.

Overload protection for the mA input is provided by F1, rated at 1A/600V. The A input is protected by F2, rated at 15A/600V. In addition, the microamp shunt resistors (R4 and R43) are protected from overload currents below the F1 fusing level by the U1 and CR1 diode network.

The Input Alert feature provides a beeper warning signal when an input jack is connected to a current input (mA or A) and the rotary switch is not set to a current function (mA or A). The Meter detects the presence of an input connection by using split jacks at the mA and A inputs. One side of the jack is connected to an overload protection resistor (R7 for mA, R10 for A). R7 and R10 are connected to U4 sense lines AP4 and AP5 (pins 89 and

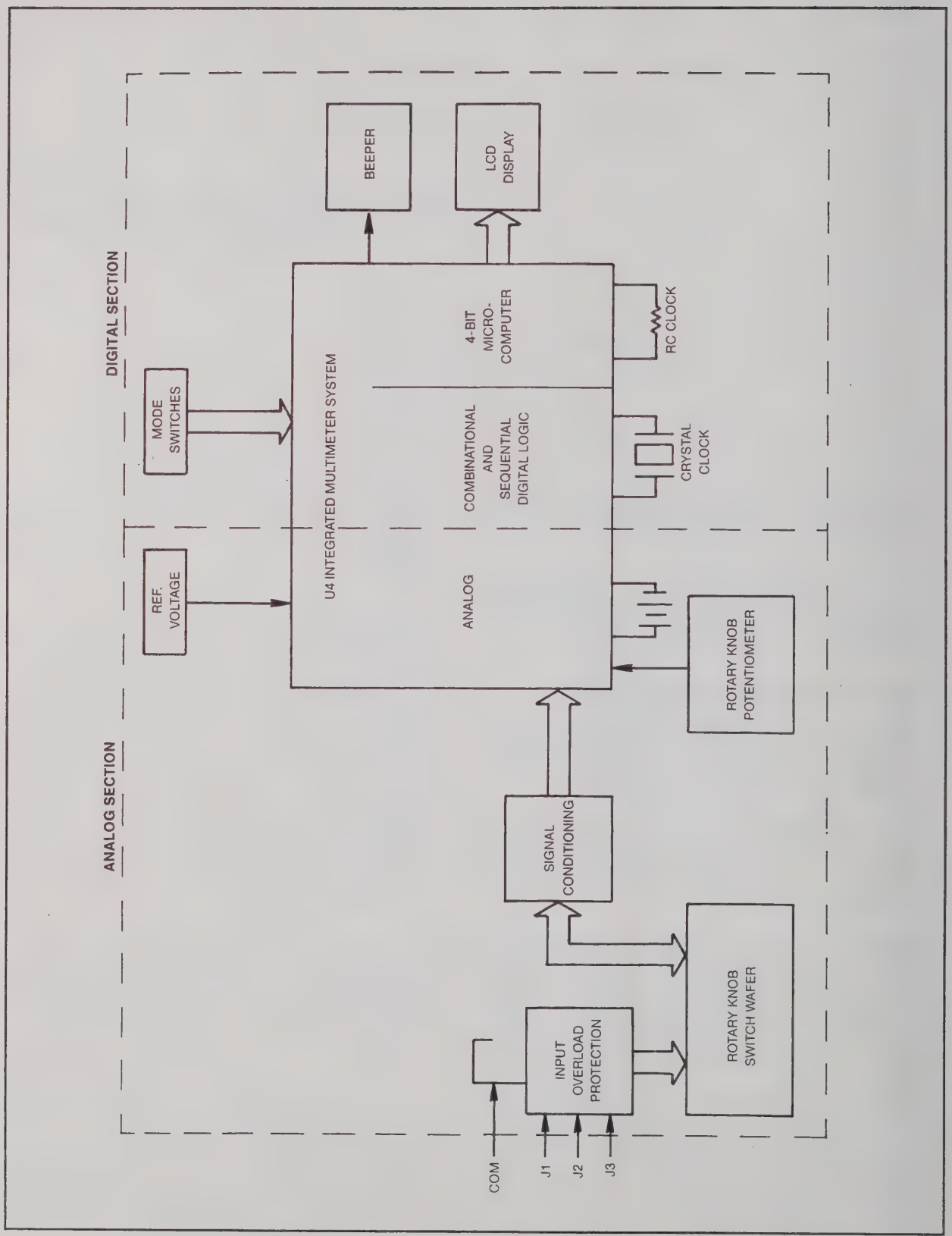


Figure 2-1. Overall Functional Block Diagram

88). Resistors R8 and R48 provide VDD pull up for AP4, and R11 is the pull up resistor for AP5. When a connection is made at mA or A, the sense side of the jack is pulled to COM. This condition is detected and compared with the selected function by U4. If a conflict exists, the beeper warning is activated.

2-5. Rotary Switch

Input signals are routed from the overload protection circuits to a double-sided switch wafer, which provides the necessary switching to implement the various signal conditioning.

2-6. Input Signal Conditioning Circuits

Each input signal is routed through signal conditioning circuitry before reaching U4. Input signals received through the V Ω ⊣⊢ input are routed through Z1, a precision resistor network. This input divider network provides precise input scaling for the various voltage ranges and precision reference resistors for the ohms and capacitance functions. The capacitors in parallel with the various resistors in Z1 are used for high frequency compensation.

The input divider is used in two modes: in voltage functions, a series mode is used to provide four divider ratios; in the ohms function, a parallel mode provides five reference resistors. During the following discussion, refer to the schematic and signal flow diagrams in Section 5.

2-7. VOLTS

In voltage functions, signal flow for input divider Z1 begins with the unknown voltage at the V Ω ⊣⊢ input, which is connected to the high end of the 9.996-MΩ resistor (pin 1 of Z1) through R1 and RT1. In ac volts, C1 is also connected in series. In dc volts, C1 is shorted by S1 (contacts 3 and 4). Internal switches connect the 9.996-MΩ and 1.1111-MΩ resistors (pin 2 to pin 3 of Z1). The low end of the 1.1111-MΩ resistor (pin 7 of Z1) is connected to COM through S1 contacts 1 and 2, producing the divide-by-10 ratio used in the 400 mV ac, 4V ac, and 4V dc ranges.

For the 40V range, internal switches connect a 101.01-kΩ resistor to provide a divide-by-100 ratio. In the 400V range, 10.01 kΩ is used for a divide-by-1000 ratio. And a 1.0001-kΩ resistor is used in the 1000V range to provide a divide-by-10000 ratio.

The internal switch resistance connecting the 1.1111 MΩ and 9.996 MΩ with the other resistors is approximately 4 kΩ. Since the a/d converter senses the voltage at APV1 of U4 (pin 3 of Z1), the internal switch resistance adds to the 9.996-MΩ resistor, making for a circuit total of 10 MΩ.

2-8. OHMS

In the 400-ohm range the internal switches connect the 9.996-MΩ resistor (pin 2 of Z1) to the 1.0001-kΩ resistor (pin 6 of Z1); contacts 5 and 3 of S1 connect the remaining ends to these resistors, making a reference resistor of 1 kΩ. Again, the 4-kΩ internal switch resistance adds to the 9.996 MΩ.

The source voltage is connected internally at both APV0 and APV4 of U4. The current is routed through the 1.0001-kΩ and 9.996-MΩ resistors, into S1 at contacts 3 and 5, out of S1 at contact 4, through R1 and RT1, out the V Ω ⊣⊢ input, through the unknown resistance, and back to COM. The same current flows through the unknown resistance and the reference resistor. The voltage dropped across the unknown resistance is sensed from the V Ω ⊣⊢ input jack through R2 and S1 (contacts 11 and 12) to AP1 of U4.

The a/d converter senses the voltage drop across the 1K reference resistor through the low (AP2 of U4 through R13) and high (APV0 and APV4) points. These two voltages are used by the a/d converter to perform a ratiometric measurement.

For the 4-kΩ range, the 10.010-kΩ resistor used in parallel with the 9.996-MΩ resistor forms a 10-kΩ reference resistor. In the 40-kΩ range, 101.01 kΩ and 9.996 MΩ form a 100-kΩ reference resistor. And in the 400-kΩ range, 1.1111 MΩ and 9.996 MΩ provide a 1-MΩ reference resistor. The 4 MΩ and 40 MΩ use only the 9.996-MΩ resistor.

2-9. Analog Section of Integrated Meter IC (U4)

The analog-to-digital converter, autorange switching, frequency comparator, and most of the remaining analog circuitry are contained in the analog section of U4. Peripherals to this U4 analog section include the crystal clock, the system reference voltage, and some filter and amplifier resistors and capacitors.

Analog-to-digital conversion is accomplished within U4 using the dual-rate, dual-slope a/d converter circuit shown in Figure 2-2. For most measurements, the basic a/d conversion cycle lasts 25 ms, for 40 measurements per second. A single conversion at this rate is called a minor cycle sample. Each minor cycle sample is used to provide 40 updates per second for the fast response bar graph display, fast MIN MAX recording, and fast autoranging.

Eight minor cycle samples are necessary to accumulate data for displaying a full-resolution (4000 count full scale) measurement on the digital display. A 40-ms autozero phase occurs following every eight-sample sequence. Therefore, each digital display update requires 240 ms, approximating 4 updates per second.

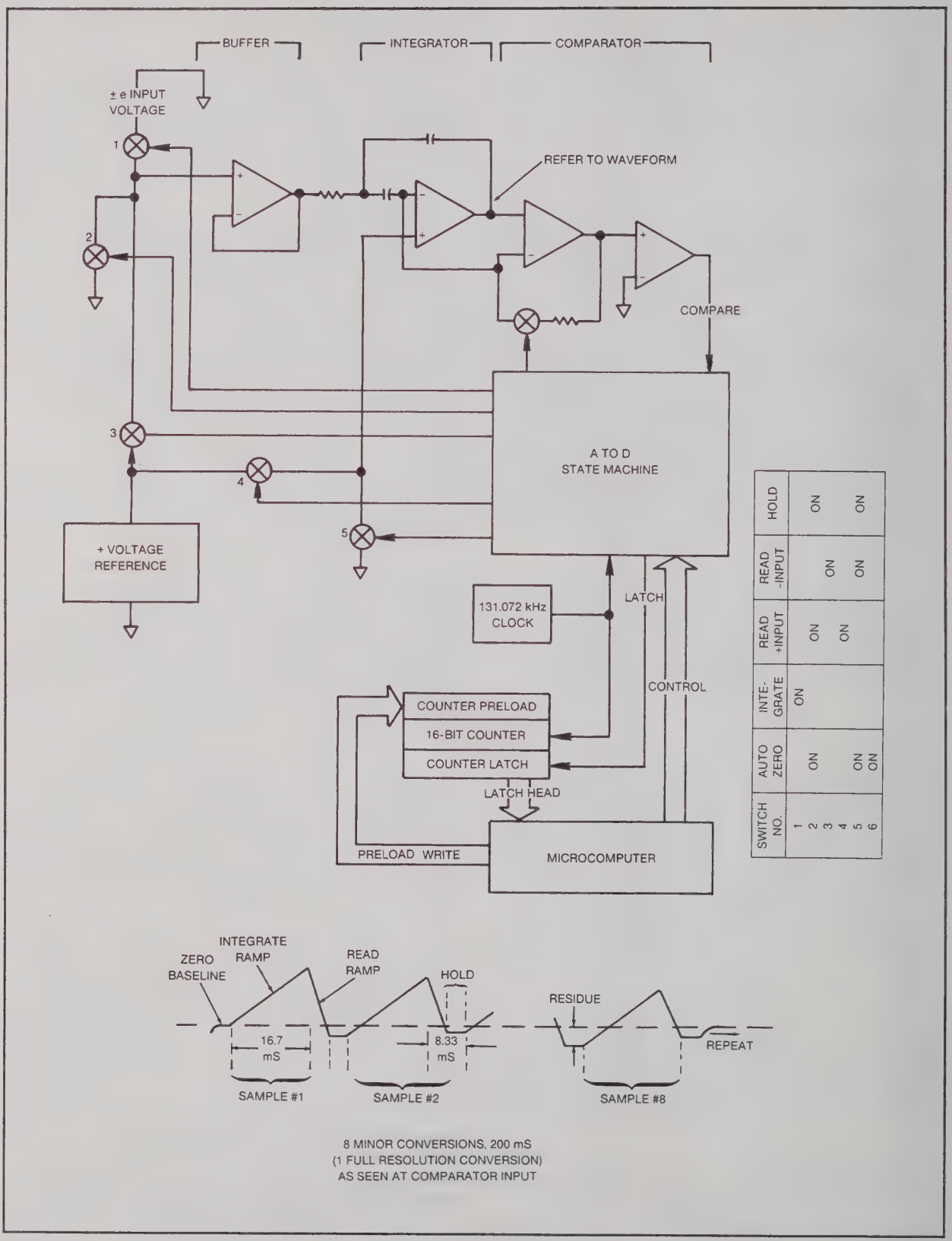


Figure 2-2. A/D Conversion

Basic a/d conversion elements and waveforms are shown in Figure 2-2. As this figure shows, a residual charge is retained by the integrator capacitor due to the overshoot past the true-zero base line. In the absence of an autozero phase, the residual charge would normally produce a significant error in the sample taken next. However, a digital algorithm eliminates the error and accounts for the residual as it propagates through all eight samples.

Basic timing for the a/d converter is defined as a series of eight integrate read cycles, followed by a 40-ms autozero phase. However, the 40-MΩ, 400-MΩ, overload recovery, autoranging, Touch Hold, 100-ms MIN MAX, and rotary switch potentiometer modes all require variations from the basic timing.

A voltage comparator, with microcomputer configurable offsets, is used for both signal detection in counter modes and threshold detection in continuity mode. In counter modes, digital pulses from the voltage comparator are routed to the 16-bit counter.

2-10. Digital Section of Integrated Meter IC (U4)

Digital circuitry in U4 (excluding the microcomputer) is partitioned into the five functional blocks below (see Figure 2-3):

- A bus control cell performs address decoding and manages selective power down, split jack sense, and low battery signals.
- The interrupt control cell manages and multiplexes four interrupts to the microcomputer. These interrupts are for 16-bit and 8-bit counter carries and voltage comparator transitions.
- A 48-bit write-only register latches microcomputer data for analog switch drive.
- A 16-bit counter (with parallel preload and latch registers) is used as a read counter for a/d conversions and as a pulse counter for frequency and duty-cycle measurements.
- The a/d converter is controlled by a 4-bit state machine with output decoding ROM.

Figure 2-4 is a block diagram of frequency counter components. For frequency and duty cycle measurements, the 16-bit counter in the digital section of U4 is partitioned into two 8-bit counters. Each of these counters is then extended to 20 bits using microcomputer software and hardware. The gating logic controls the start and stop of each reading.

When measuring frequency, signal A is the unknown frequency, and signal B is the crystal clock signal. After enough counts have been accumulated in each 20-bit register, the microcomputer calculates the unknown frequency from the ratio of the counter values.

When making duty cycle measurements, signal A (Figure 2-4) is again the unknown signal, but signal B is the logical AND of the unknown and reference signals. As with frequency measurement, the microcomputer controls the start and stop of a measurement cycle via the gating logic. The ratio of the counter values yields the duty cycle. Pulse width is calculated from frequency and duty cycle measurements.

2-11. Microcomputer Control

A 4-bit microcomputer, integrated within U4, controls the various Meter functions and drives the display. A/D converter and counter measurements are controlled via the microcomputer interface lines shown in Figure 2-3. The MIN MAX, Touch Hold, and ZERO (relative) modes involve additional data processing by the microcomputer to generate the display value.

The microcomputer/digital logic interface consists of both RAM that has been mapped into the digital logic and an interrupt line back to the microcomputer. The four interrupts can be masked, read, and reset. Note that the microcomputer runs on its own RC clock at a frequency of 525 to 800 kHz and is asynchronous from the crystal clock.

The microcomputer exercises direct control over the ranging and signal routing analog switches. A specific word is written to the switch drive register for each function/range selection. When the Meter is in autorange, the microcomputer determines the correct range based on the input. In addition, for autoranging during voltage, ohms, or current measurements, the active filter fast mode is enabled for quick response. In the frequency or duty cycle mode, pressing the RANGE button causes a range change in the primary function (volts, amps, etc.) that may change the sensitivity or offset.

The microcomputer sets the required a/d converter mode, which determines the on-chip analog signal ports to be used for the integrate and de-integrate signals. The microcomputer also selects one of the three available gain resistors in Z1 for integrate and de-integrate. All voltage and current conversions use either a 400-mV or a 40-mV full scale mode. Other modes are used for ohms, 4 MΩ, 40 MΩ, and 400 MΩ. Since the a/d state machine timing is under direct software control, a mode invoked in another function or range can use different timing.

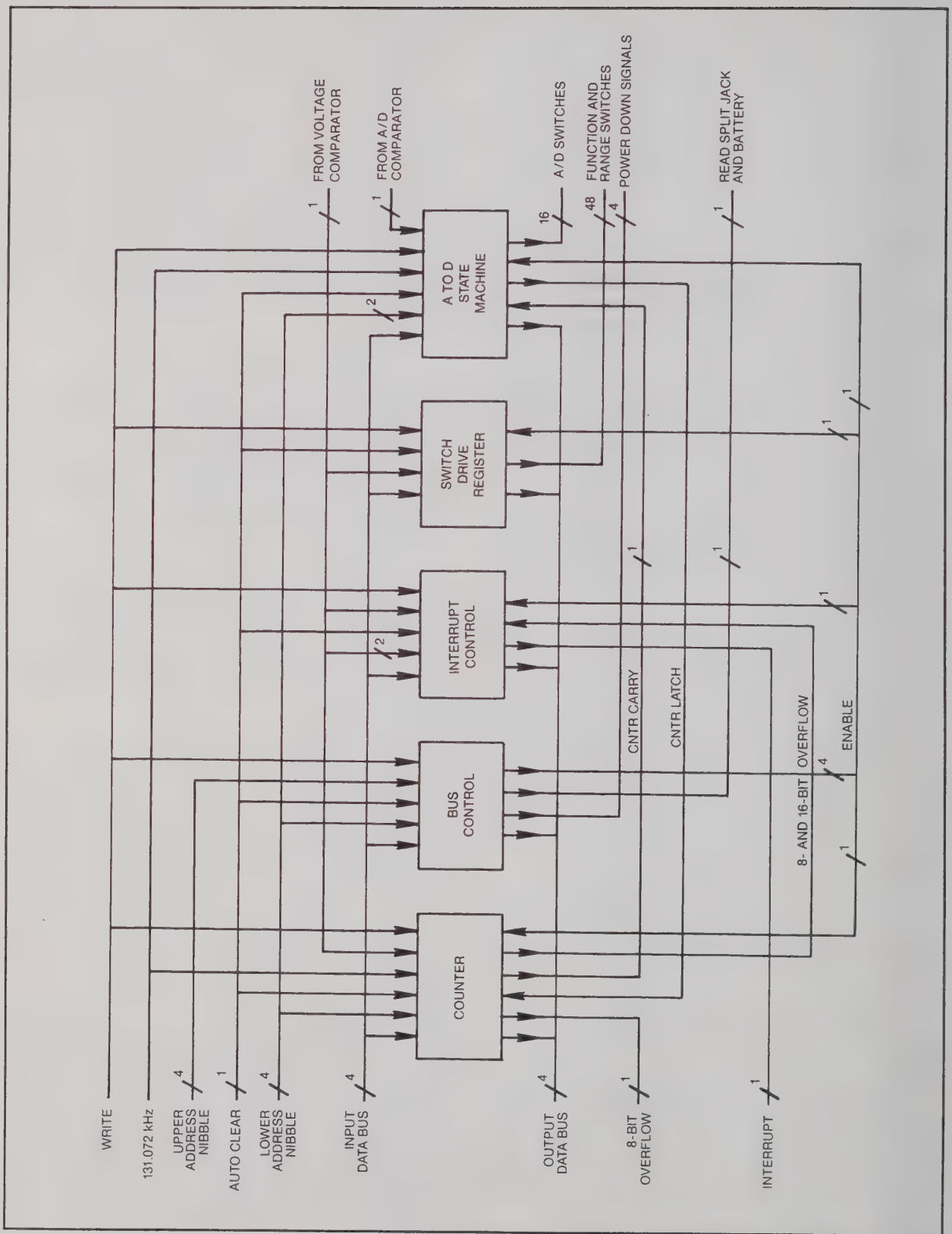


Figure 2-3. Digital Circuitry Within U4

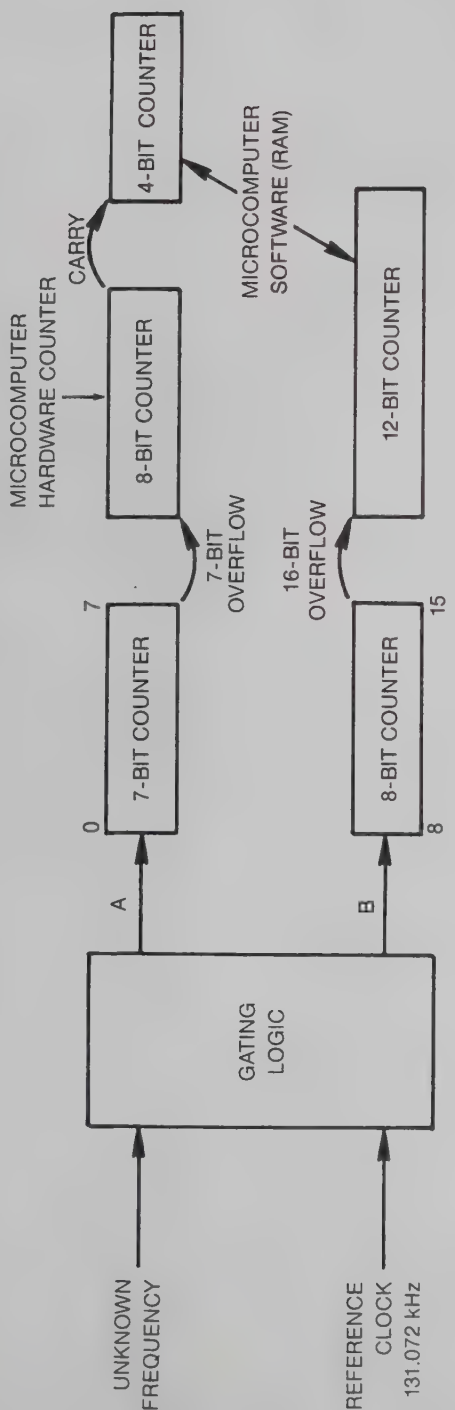


Figure 2-4. Frequency Counter Elements

Counter measurements are also controlled by the microcomputer section of U4. The microcomputer initializes the counters, monitors the count accumulation, arms and disarms the logic signal gating, and calculates the display value from the counter values.

MIN MAX Recording, Touch Hold, and ZERO (relative) are secondary software functions. This means that the microcomputer performs either a different control algorithm or a different math routine on the data, as explained below.

- In the MIN MAX Recording function, the maximum and minimum readings after initialization are stored in memory, and a true running average is calculated after each reading. The running average is updated for a maximum of 36 hours. The user presses the MIN MAX pushbutton to scroll through the minimum, maximum, average, and present readings. In the 100 ms MIN MAX mode, a single measurement sample is used to calculate the display value; in the 1 second MIN MAX mode, a full resolution conversion is used.

- When the Touch Hold function is selected, the microcomputer does not allow a full resolution conversion to be completed unless the input signal is stable. When a stable reading occurs, the conversion is completed, and the microcomputer generates and freezes the corresponding display. The microcomputer now waits for a change in the signal to exceed a certain threshold, then begins watching for a stable reading again. Note that a reading is forced when Touch Hold is first selected. Also, open test lead signals do not update the display.

- When the ZERO function is selected, the microcomputer stores the present reading as an offset. This value is subtracted from all subsequent readings (provided that they are on scale) to give the display value.

2-12. Peripherals to U4

In addition to input overload protection and input signal conditioning circuits, other devices peripheral to U4 are needed to support Meter features. The ac converter, active filter, and a/d converter circuits require off-chip resistors and capacitors. Digital drive and level-shifting circuits are needed for the beeper drive, quick turn off, and LCD backlight (Fluke 88 only) features. A voltage reference is generated separately from U4, and some discrete resistors and transistors support the power supply.

2-13. AC BUFFER

On the Meter, R14, R15, C5, and C27 are part of the ac buffer circuit that drives the ac converter and guard. The Meter's ac buffer can be configured for an ac gain of 1 or 10.

2-14. AC CONVERTER

The Meter's average ac converter uses off-chip components R30, R31, R34, R40, C24, C28, and C29. This ac converter is a full-wave rectifying converter with a differential output and gain selected to give a dc output equal to the rms value for a sine wave input. Filtering is provided by C28 and C29.

2-15. ACTIVE FILTER

The active filter uses off-chip passive components R17, R18, C8, and C9. It is a second order, low pass filter with two poles at 5.9 Hz in normal mode that filters input signal noise and ac ripple from the ac converter, yielding stable a/d converter readings. The microcomputer can disable the filter completely or enable the filter fast response mode.

2-16. A/D CONVERTER

Pins 8, 9, and 10 on precision resistor network Z1 connect to the three a/d converter gain resistors. Pin 8 connects to 190 kΩ for a gain of 0.87. Pin 9 connects to 160 kΩ for a gain of 1, and pin 10 connects to 16 kΩ for a gain of 10. Pin 11 is the common connection. The autozero capacitor (C10) stores op amp and comparator offsets. The integration capacitor is C11.

2-17. BEEPER

Devices Q9, Q11, R56, R57 and CMOS hex inverter U6 make up the double-ended beeper drive circuit. Transistor Q12 is connected to provide quick microcomputer power down when the Meter is turned off.

2-18. REFERENCE VOLTAGE

The system reference voltage (1.235V) is generated by VR1 and R44. The 1.000V reference voltage for the a/d converter is supplied through U4-1 (REFI). This voltage is adjusted by R21, the dc calibration potentiometer. In addition to generating the a/d reference, the VR1 voltage is used for power supply reference, voltage comparator selectable offset generation, and the ohms source level.

2-19. POWER SUPPLY

The power supply consists of two regulators, one shunt and one series, which set VDD at +3.0V and VSS at -3.2V for all battery voltages down to 6.7V. The shunt (common) regulator sets |VDGND - VSS| (VDGND = COM = 0V)

and consists of an uncompensated op amp and large current shunt devices integrated on U4. Resistors R37 and R38 provide voltage division. The series (VDD) regulator, which sets |VDD - VDGND|, is made up of another on-chip, uncompensated op amp, along with devices Q3, R24, and R25. Q3 is the series regulator element, and R24 and R25 are for voltage sensing. Capacitors C14 and C21 provide circuit compensation and power supply decoupling for the shunt and series regulators, respectively. Voltage level information is presented in Table 2-1. See Figure 3-7 for a simplified schematic of the power supply.

Table 2-1. Typical Voltage Levels and Tolerance

SIGNAL	TYPICAL VOLTAGE LEVELS
VDD	3.0 ±0.3
VSS	3.2 ±0.3
VBT+	3.5 ±0.3
VBT-	5.5 (battery at full 9V charge) 3.0 (battery at low charge of 6.5V)
REFH	1.235 ±0.012
PS0	1.235 ± 0.15
PS1	0 ±0.15
AP6	-0.5 to -0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to .85(referenced from VSS)

2-20. Display

The liquid-crystal display (LCD) operates under direct control of the microcomputer. Characters are generated by the computer and displayed on the LCD. Both digital readings and the analog pointer are displayed in conjunction with annunciators. The Fluke 88 features a transflective LCD with a light-emitting diode (LED) backlight. Refer to the Fluke 86/88 Users Manual for a more detailed description of the display.

2-21. Function-Encoding Potentiometer

The function-encoding potentiometer is attached to the rotary switch shaft. When the meter is turned on or the rotary switch is moved to a different setting, U4 performs a voltage ratio measurement on this potentiometer to determine the new function. See Figure 2-5.

The potentiometer is made of a polymer thick film (PTF) that is screened on the back of the pca (see Figure 2-6). It is comprised of three separate sections.

The outer section of the potentiometer is the resistor section, which can have an end-to-end resistance of between 50 and 200 kΩ. This resistance is divided equally between the six detent function positions. A voltage drop of 400 mV is also divided equally between the detent positions of the resistor. These voltages provide the Integrate and De-Integrate voltage used for the voltage ratio measurement. The Integrate voltage is developed between VDGND and the rotor contacts, while the DE-Integrate voltage (Ref Voltage) is present across the outer section. The Integrate voltage steps linearly as the function switch is rotated to the various detent positions. To determine the Meter function, U4 compares the voltage ratio measurement data with data stored in its memory.

The middle section of the potentiometer acts as an interrupt. Each time the potentiometer contact is moved over an interrupt section, a logic 0 interrupts the a/d converter. As the contacts come to rest on the detent position, a logic 1 resets the digital logic and causes the a/d converter to take a voltage ratio measurement.

The center section of the potentiometer serves as a contact bar to route resistor voltages and logic signals to the analog chip U4. A separate part of this section is also used to route the power down signal (PDS) to the power supply.

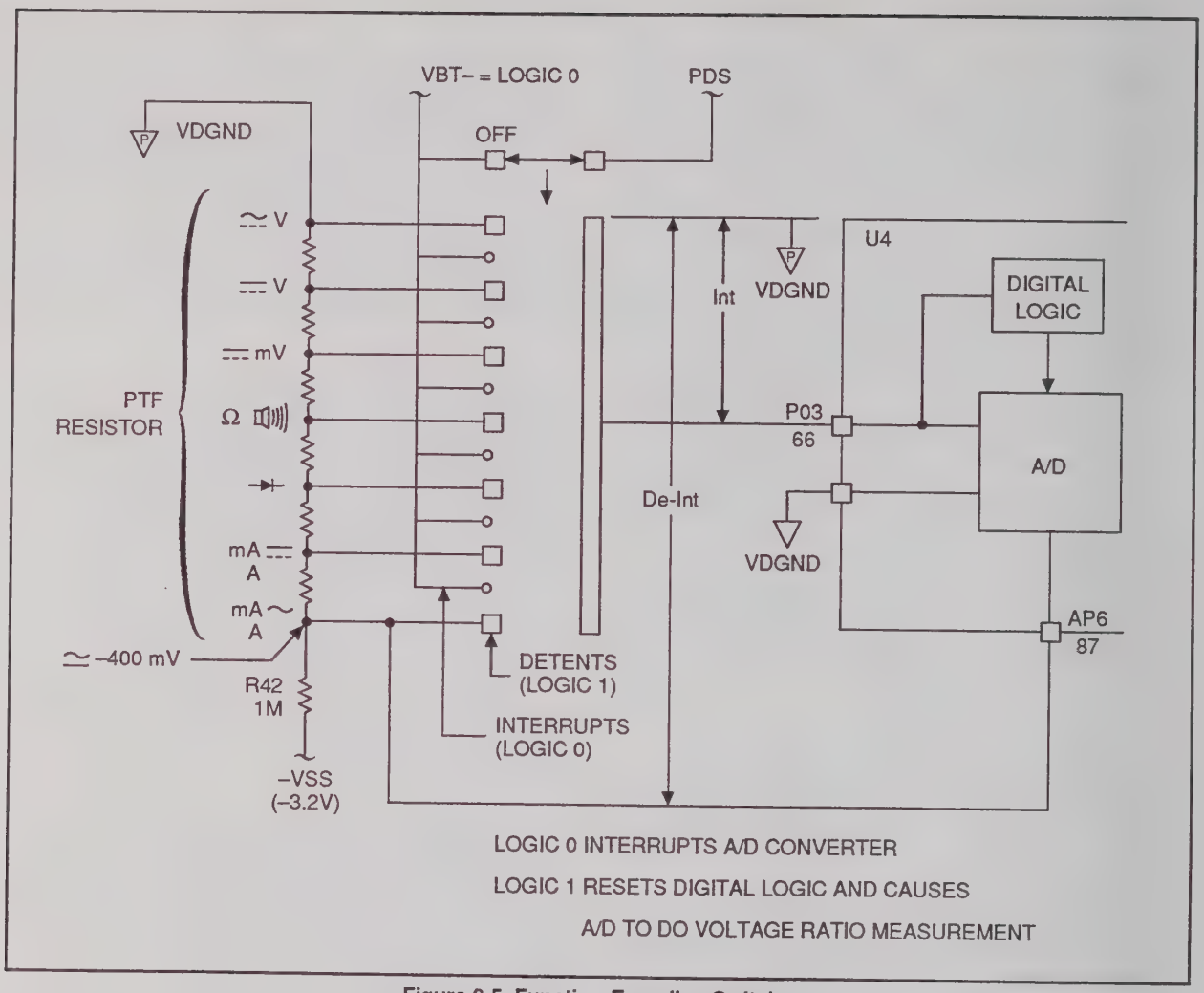


Figure 2-5. Function-Encoding Switch

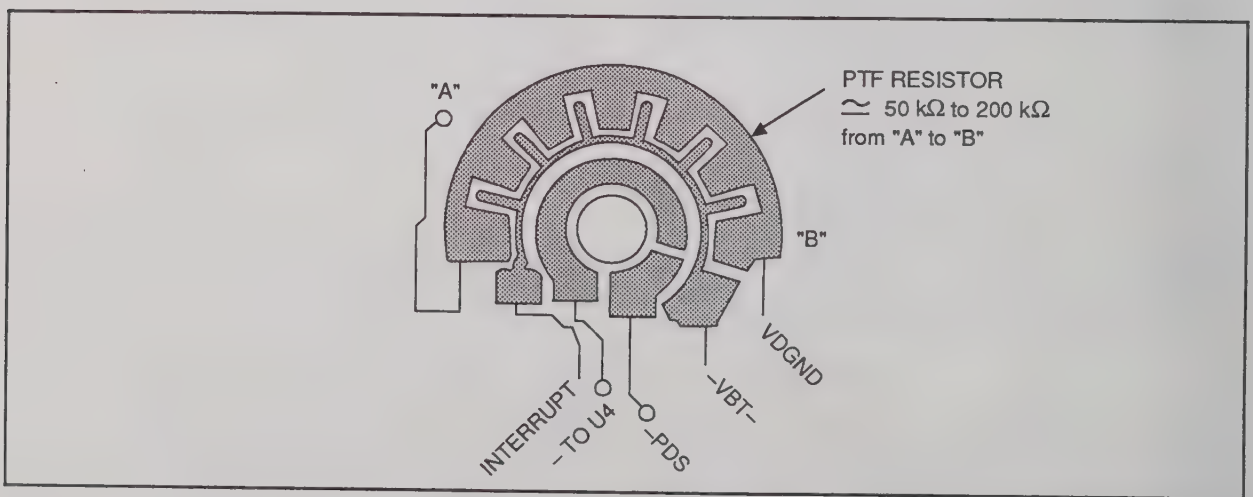
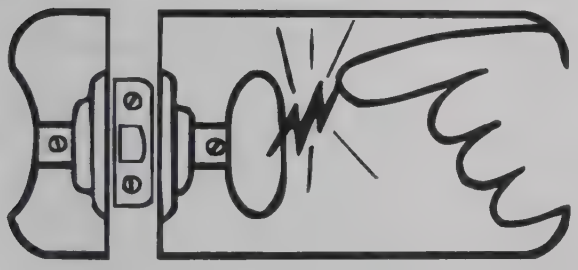


Figure 2-6. Polymer Thick Film

static awareness

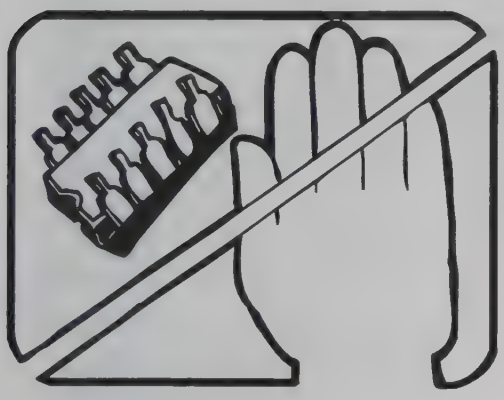
A Message From
Fluke Corporation



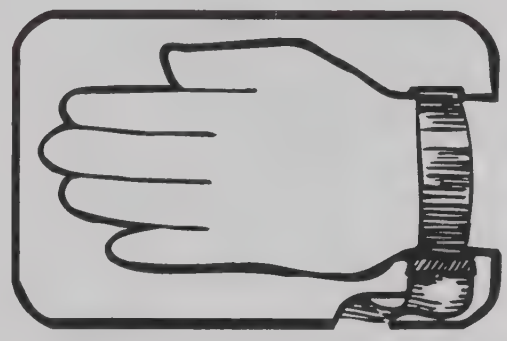
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Leaning the guidelines for handling them.
3. Using the procedures, packaging, and bench techniques that are recommended.

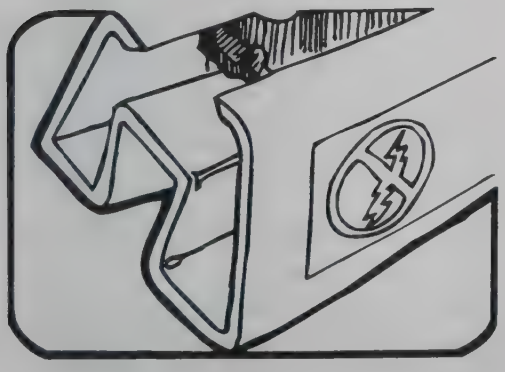
The following practices should be followed to minimize damage to S.S. (static sensitive) devices.



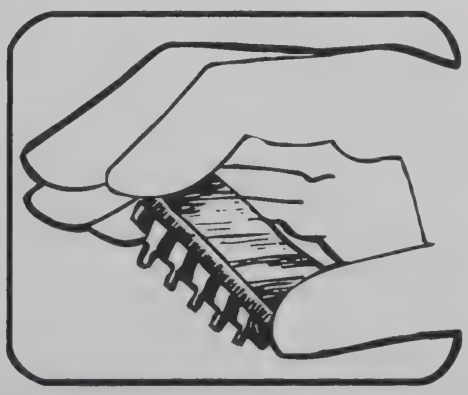
1. MINIMIZE HANDLING



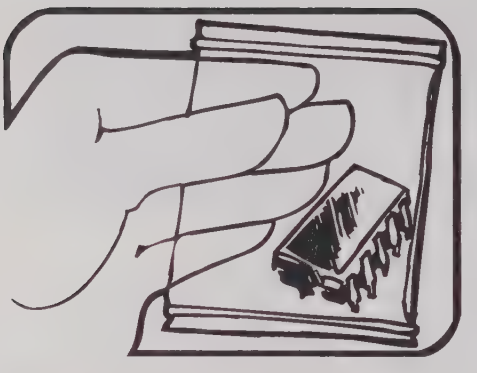
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



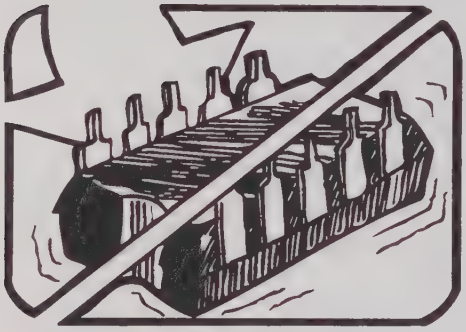
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



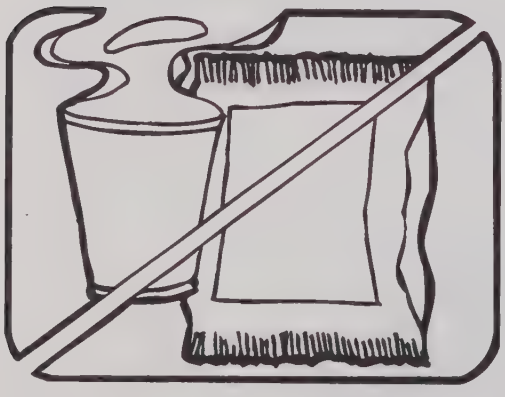
4. HANDLE S.S. DEVICES BY THE BODY.



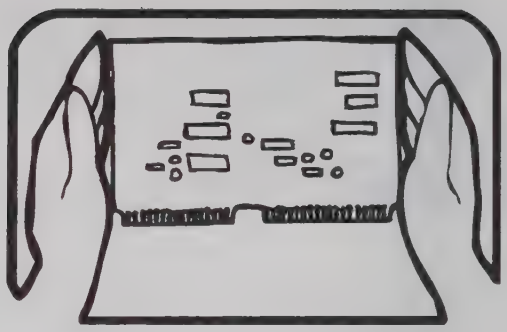
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT.



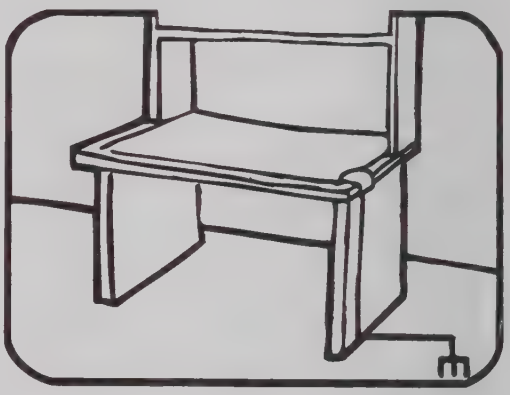
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE.



7. AVOID PLASTIC,VINYL AND STYROFOAM® IN WORK AREA.



8. WHEN REMOVING PLUG-IN ASSEMBLIES HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS PROTECT INSTALLED S.S. DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION.

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED-TIP SOLDERING IRONS SHOULD BE USED.

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Section 3
Maintenance

WARNING

SERVICE PROCEDURES DESCRIBED IN SECTION 3 SHOULD PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.

3-1. INTRODUCTION

Section 3 covers the following procedures:

- Maintenance
- Disassembly and reassembly
- Performance testing
- Calibration
- Troubleshooting to the component level

3-2. REQUIRED TOOLS AND EQUIPMENT

Required equipment is listed in Table 3-1. If the recommended models are not available, equipment with equivalent specifications may be used. Repairs or servicing should be performed only by qualified personnel.

3-3. OPERATOR MAINTENANCE

WARNING

TO AVOID ELECTRICAL SHOCK, REMOVE THE TEST LEADS AND ANY INPUT SIGNALS BEFORE REPLACING THE BATTERY OR FUSES. TO PREVENT DAMAGE OR INJURY, INSTALL ONLY QUICK-ACTING FUSES WITH THE AMP/VOLT RATINGS SHOWN IN FIGURE 3-1.

3-4. Disassembing the Case

Perform the following procedure to disassemble the case:

1. Disconnect the test leads from any live source, turn the Meter rotary switch to OFF, and remove the test leads from the front terminals.

2. The case top is secured to the case bottom by three screws and two internal snaps (at the LCD end). Using a Phillips-head screwdriver, remove the three screws from the case rear.

NOTE

The gasket between the case top and case bottom is sealed to the case bottom. The case top lifts away from the gasket easily. Do not damage the gasket or attempt to separate the gasket from the case bottom.

3. Turn the case over (display side up), and, lifting up on the input terminal end, disengage the case top from the gasket. Gently unsnap the case top at the display end. See Figures 3-1 and 3-2.

CAUTION

With its case removed, circuit connections are exposed. To avoid unintended circuit shorting, always place the uncovered Meter assembly on a protective surface.

3-5. Removing and Reinstalling the Circuit Assembly

After the outer case has been removed, perform the following procedure to disconnect the covering shields from the circuit assembly:

Table 3-1. Required Equipment

EQUIPMENT	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
DMM Calibrator	AC Voltage Range: 0-1000V ac Accuracy: ±.05% Frequency Range: 40-20000 Hz Accuracy: ±1% DC Voltage Range: 0-1000V dc Accuracy: ±.05% Current Range: 34-350 mA Accuracy: ±.2%	Fluke 5100B, 5101B, 5102B, 5700A + 5725A, or 5500A
Function Generator	Triangle Wave N Cycle (Single Cycle) 1 MHz 20V Output unterminated	Philips PM 5133 or 5134
Oscilloscope	60 MHz, 30% vertical error 10M scope probe	Philips PM 3055
Power Amplifier	Range: to 1000V ac Accuracy: 50 Hz to 10 kHz: ±(800 ppm + 100 mV) 10 to 50 kHz: ±(1200 ppm + 150 mV)	Fluke 5205A
Resistance Calibrator	Range: 190Ω-100 MΩ Accuracy: 0.1%	Fluke 5450A or General Resistance RDS-77B
Transconductance Amplifier	Current Range: 10A Accuracy AC (60 Hz to 1 kHz): ±.3% DC: ±.1%	Fluke 5220A
Adapter	Binding Post to BNC Male	Pomona Model 1296
10-Ohm Resistor	±1%	NA
14-AWG Wire	1-ft, insulated	NA

Table 3-1. Required Equipment (cont)

	EQUIPMENT USED IN PERFORMANCE TESTS				
	DMM CALIBRATOR	FUNCTION GENERATOR	POWER AMPLIFIER	RESISTANCE CALIBRATOR	OSCILLOSCOPE
AC Voltage	X		X		
Frequency					
Accuracy		X			
Sensitivity		X			
Trigger Level		X			
DC Voltage	X				
mV DC	X				
Ohms				X	
Diode	X				
mA	X				
A	X				
RPM/Inductive Pickup		X			X

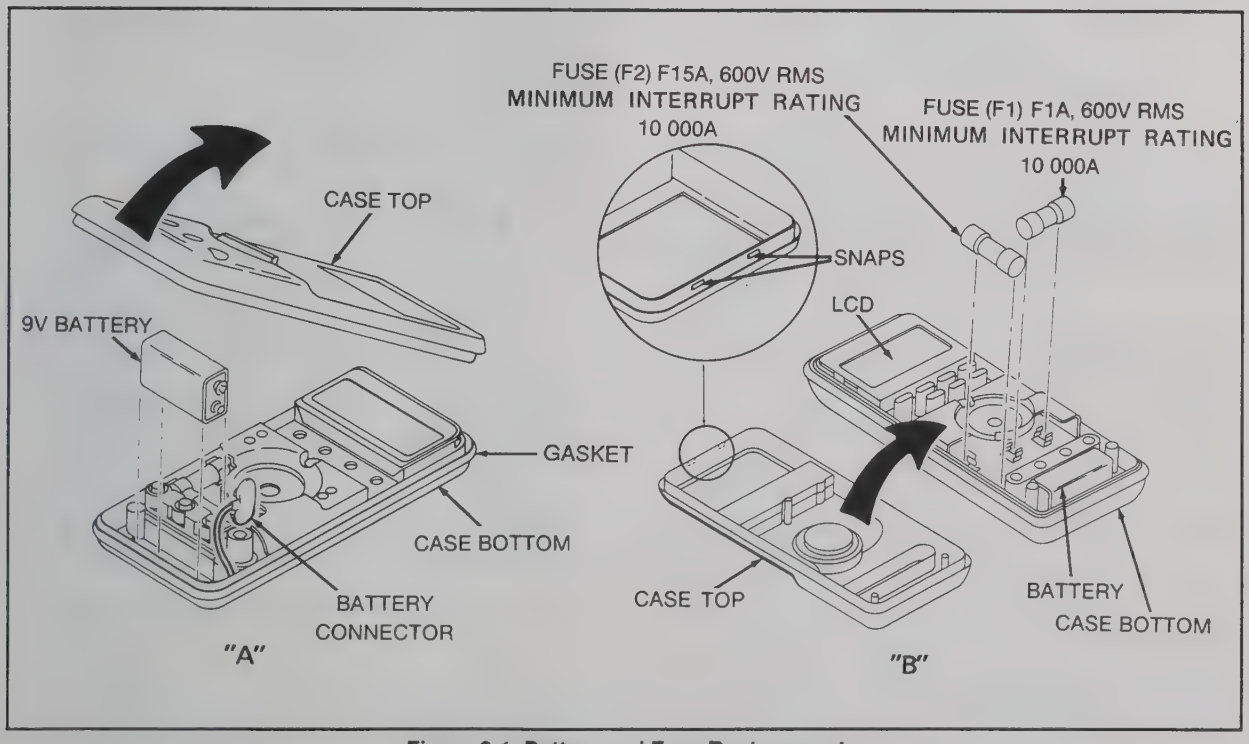


Figure 3-1. Battery and Fuse Replacement

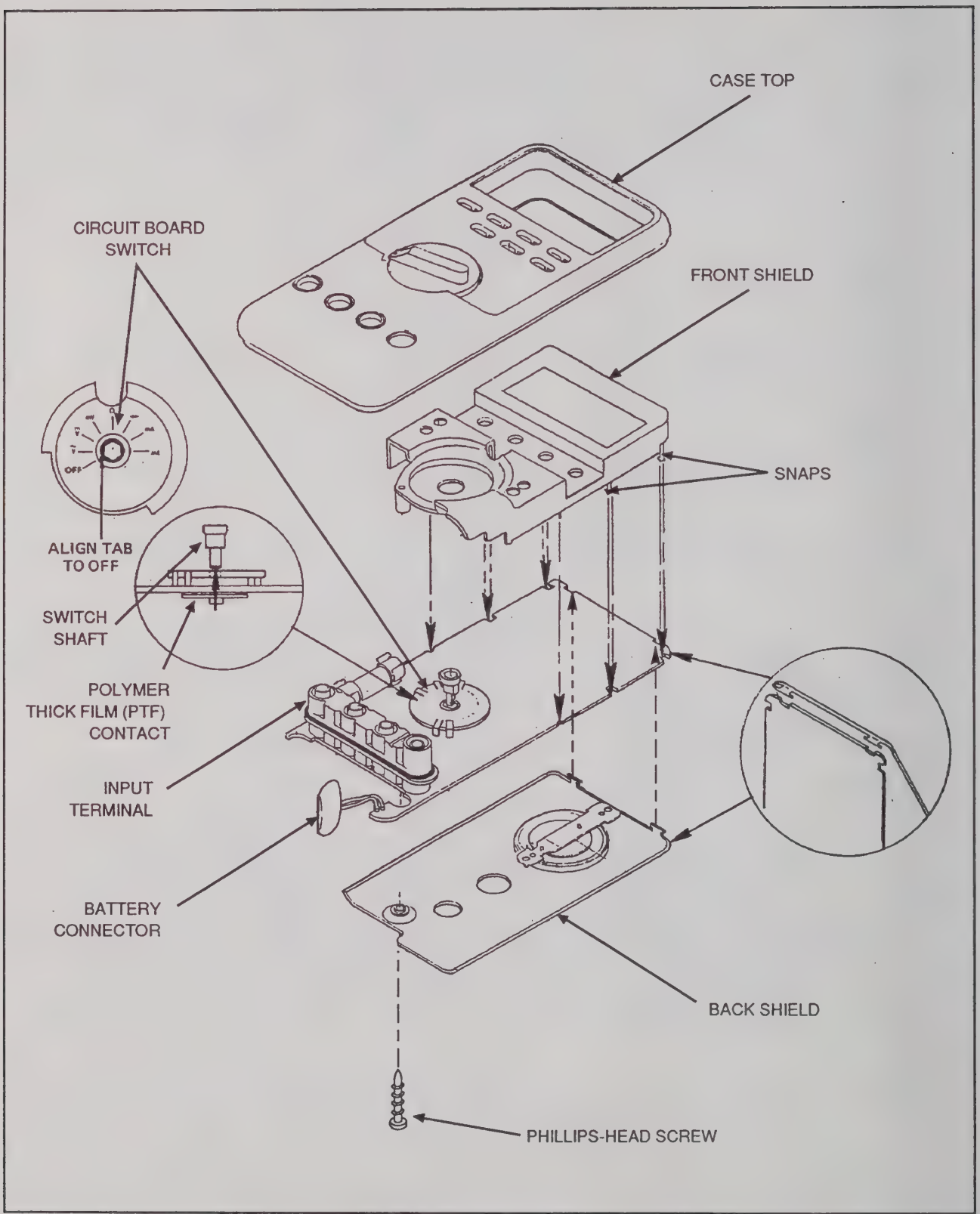


Figure 3-2. Assembly Details

1. Unsnap the battery from the battery connector.

2. Carefully remove the assembly from the case bottom and turn the assembly over.

3. Remove the one Phillips-head screw securing the back shield to the circuit assembly. Then remove the back shield.

4. The front shield can now be disconnected from the circuit assembly by detaching the four snaps (one at a time) found on the front shield.

CAUTION

Detach the four securing snaps gently. Excessive force can deform or fracture the snaps.

5. To reattach the circuit assembly, push the front shield on so that the four clips engage gently and simultaneously. Then turn the assembly over, and replace the back shield and Phillips-head screw.

NOTE

Ensure that the shields are tightly attached. Meter accuracy depends on properly fitted shields.

6. Gently place the assembly back in the case bottom.

7. Snap the battery to the battery connector and reinsert the battery in the case bottom.

3-6. Reassembling the Case

Perform the following procedure to reassemble the case.

1. Make sure that the Meter rotary switch and circuit board switch are in the OFF position (see Figure 3-2).

2. Dress the battery leads so that they will not be pinched between the case top and bottom.

3. Ensure that the gasket remains secured to the case bottom.

4. Starting with the two snaps at the display end and finishing at the terminal end, cradle the case top into the gasket.

5. Reinstall the three screws from the case bottom.

6. Execute the PERFORMANCE TEST procedures later in Section 3.

3-7. Replacing the Battery

The meter is powered by a single 9V battery (NEDA 1604, 6F22, or 006P). Referring to Figure 3-1, perform the following procedure to replace the battery:

1. Remove the Meter case as described previously under "Disassembling the Case".

2. Lift the battery from the case bottom, and carefully unsnap the battery from the battery connector.

3. Snap the battery connector to the terminals of a new battery and reinsert the battery into the case bottom. Dress the battery leads so that they will not be pinched between the case bottom and case top.

4. Reassemble the Meter as described under "Reassembling the Case".

3-8. Testing Fuses

Perform the following procedure to test the internal fuses of the Meter.

1. Set the Meter rotary switch to •))) Ω.

2. Plug a test lead into the V Ω →|← input terminal, and touch the probe to the A input terminal. Because the receptacles of the input terminals contain split contacts, be sure that you touch the probe to the half of the receptacle contact that is nearest the LCD.

3. The display should read between 00.0 and 00.5 ohms. This tests F2 (15A, 600V). If the display reads OL (overload), replace the fuse and test again. If the display reads any other value, further servicing is required.

4. Move the probe from the A input terminal to the mA input terminal.

5. The display should read between 0.995 kilohms and 1.005 kΩ. This procedure tests F1 (1A, 600V). If the display reads a high resistance or OL (overload), replace the fuse and test again. If the display reads any other value, further servicing is required.

3-9. Replacing Fuses

Referring to Figures 3-1 and 3-2, perform the following procedure to examine or replace the meter's fuses:

1. Perform steps 1 through 3 of the battery replacement procedure.

2. Remove the defective fuse by gently prying one end of the fuse loose and sliding the fuse out of the fuse bracket.

3. Install a new fuse of the same size and rating. Make sure the new fuse is centered in the fuse holder.

4. Make sure that the Meter rotary switch and circuit board switch are in the OFF position.

5. Ensure that the gasket remains secured to the case bottom. Then, starting with the two snaps at the display end and finishing at the terminal end, cradle the case top into the gasket.

6. Reinstall the three screws from the case bottom.

3-10. Cleaning

WARNING

TO AVOID ELECTRICAL SHOCK OR DAMAGE TO THE METER, NEVER ALLOW WATER INSIDE THE CASE. TO AVOID DAMAGING THE METER'S HOUSING, NEVER USE SOLVENTS ON THE METER.

If the Meter requires cleaning, wipe it with a cloth that is lightly dampened with water or a mild detergent. Do not use aromatic hydrocarbons, chlorinated solvents, or methanol-based fluids on the Meter.

3-11. INPUT TERMINALS

Water, dirt, or other contamination in the A or mA terminals may activate the Input Alert (beeper) even though test leads are not inserted. Such contamination can sometimes be dislodged by turning the Meter over and gently tapping on the case. However, Fluke recommends the following procedure as a much more effective treatment:

1. Turn the Meter off and remove all test leads.

2. Use a clean swab in each of the four terminals to dislodge and clean out the contamination.

3. Moisten a new swab with a cleaning and oiling agent (such as WD40). Work this swab around in the A and mA input terminals.

   The oiling agent insulates the terminals from moisture-related shorting. This preventive treatment ensures against future erroneous Input Alerts.

3-12. FUNCTION ENCODING POTENTIOMETER

Perform the following procedure to clean the rotary switch potentiometer, which is screened on the back of the pca board (see Figure 2-6):

1. Remove the circuit assembly as described previously in this section under "Removing and Reinstalling the Circuit Assembly".

2. From the back of the circuit assembly, push the switch shaft in (see Figure 3-2), and remove the polymer thick-film (PTF) contact assembly.

3. Clean the PTF contact assembly and the potentiometer on the circuit assembly with alcohol. Blow these parts dry with clean, dry air.

4. Push and secure the ptf contact assembly back on the switch shaft.

5. Reassemble the circuit assembly, shields, and case parts as described previously in this section under "Removing and Reinstalling the Circuit Assembly" and "Reassembling the Case".

6. Execute the PERFORMANCE TEST after reassembly.

3-13. PERFORMANCE TEST

Perform the following procedure to check basic Meter operations:

1. Turn the Meter rotary switch to Ω.

2. Plug a test lead into the V Ω →|← input. Using the probe end of the test lead, touch the half of the input contact nearest the LCD of the mA input.

   The display should read 1.000 kΩ ± 5 digits.

3. Remove the test probe from the mA input.

4. Push the ALERT key on the bottom row of the softkeys.

5. Place the test probe in the A input, touching the contact nearest the LCD.

The beeper sounds if the mA fuse (15A) is good.

The following paragraphs provide a more complete check of the Meter's accuracy and operability.

The accuracy of each Meter function is compared to the specifications for that function listed in Section 1 of this manual. The case covers do not need to be removed and no adjustments are necessary. Merely make the input connections called for, and read the display. If the Meter fails any of the performance tests below, calibration adjustment and/or repair is required.

The equipment required to perform these tests is listed in Table 3-1. Specified accuracy is maintained for a period of one year after calibration, at an operating temperature of 18°C to 28°C and at a maximum of 90% relative humidity.

3-14. Testing the Display

With the Meter rotary switch in the OFF position, press and hold down any pushbutton and turn the rotary switch to any function setting.

The display should appear as shown in Figure 3-3.

Figure 3-3. Display Test

3-15. Testing Function Selection (Rotary Switch)

The function selection test checks the operation of the rotary switch function selector circuit.

The selector circuit relies on the interface between a PTF region on the circuit assembly and a rotating contact assembly on the switch shaft. The function selection test exercises this interface by checking the various range codes and displaying their representative numbers.

Perform the following procedure to test the function selector circuit.

1. Press and hold down (RPM) pushbutton while turning the rotary switch from OFF to ~V . This enables the function selection test and disables normal Meter functions. T (for test) is shown on the display, and a number appears in the display.

2. Compare the display reading with the value for ~V shown in Table 3-2. This reading should be within ± 12 of the number for ~V in Table 3-2. If it is not, refer to TROUBLESHOOTING A FUNCTION SELECTION MALFUNCTION later in Section 3.

3. Rotate the switch to ⎓ V . The display reading should be within ± 12 of the ⎓ V value shown in Table 3-2.

Table 3-2. Function Selection Test

FUNCTION	DISPLAY (±12)	FUNCTION	DISPLAY (±12)
OFF	n/a	Ω	-96
~V	0	→|	-128
⎓ V	-32	mA⎓ A~	-160
⎓ mV	-64	μA⎓ ~	-192

4. Test the remaining function settings on the rotary switch as in step 3.

5. To exit the function selection test, turn the rotary switch to OFF, then turn it to any switch setting.

3-16. Testing the AC Voltage Function

Perform the following procedure to verify accuracy of voltage ranges.

1. Connect the calibrator to the V Ω →| and COM inputs on the Meter.

1a. Set the meter rotary switch to ~V and press the range button for two seconds to select the auto-range.

2. Set the calibrator for the voltage and frequency called for in step 1 of Table 3-3. The display reading should be within the limits shown in Table 3-3.

3. Repeat the previous step (Step 2) for steps 2 through 6 of Table 3-3.

4. Connect the power amplifier between the calibrator and the Meter.

5. Check the accuracy at each input for steps 7 through 10 of Table 3-3.

6. Turn the meter off.

Table 3-3. AC Voltage Test

STEP	INPUT		DISPLAY READING LIMITS
	VOLTAGE	FREQUENCY	
1	350.0 mV	60 Hz	343.7 to 356.3
2	350.0 mV	1 kHz	343.7 to 356.3
3	350.0 mV	5 kHz	342.3 to 357.7
4	3.500V	60 Hz	3.442 to 3.558
5	3.500V	1 kHz	3.442 to 3.558
6	3.500V	5 kHz	3.428 to 3.572
7	35.00V	60 Hz	34.42 to 35.58
8	35.00V	1 kHz	34.42 to 35.58
9	35.00V	5 kHz	34.28 to 35.72
10	350.0V	60 Hz	344.2 to 355.8
11	350.0V	1 kHz	344.2 to 355.8
12	350.0V	5 kHz	342.8 to 357.2
13	900V	60 Hz	872 to 928
14	900V	5 kHz	872 to 928

3-17. Testing the Frequency Counter Function

Perform the following procedure to verify the accuracy in frequency counter functions.

1. Connect the function generator to the V Ω ⊣⊢ and COM inputs on the Meter.
2. Turn the rotary switch to ~V , and press the RANGE button four times to put the Meter in the 400 mV ac range.
3. Press the RPM (Hz) pushbutton three times to select the frequency function.
4. Set the function generator for the sine wave voltage and frequency called for in step 1 of Table 3-4. The value displayed should be within the limits shown in step 1 of Table 3-4. Repeat for step 2.

Table 3-4. Frequency Test

STEP	SINE WAVE INPUT		DISPLAY READING LIMITS
	VOLTAGE	FREQUENCY	
1	150 mV rms	19.000 kHz	18.997 to 19.003
2	150 mV rms	190.00 kHz	189.97 to 190.03

3-18. Testing Frequency Sensitivity and Trigger Level

The following procedure verifies the counter sensitivity and trigger levels for all frequency modes and ranges. For any function and range, the sensitivity and trigger level is the same in both frequency and duty cycle modes.

1. Connect the DMM calibrator to the V Ω ⊣⊢ and COM inputs on the Meter.
2. Select the 4V ac range, and press the RPM button to choose the frequency mode.
3. Apply the input from step 1 of Table 3-5, and check for the called-for response.
4. Select the 4V dc range, and press the RPM button to select frequency mode.
5. Apply the input from step 2 and step 3 of Table 3-5, and check for the called-for response.
6. On the Meter, press the RANGE button to enter the 40V dc range.
7. Apply the step 4 and step 5 input and check for the called-for responses on the Meter.

3-19. Testing the DC Voltage Function

Perform the following procedure to verify the accuracy of dc voltage measurements. (A separate verification procedure for dc millivolts (mV) is provided later in this section.)

1. Connect the calibrator to the V Ω ⊣⊢ and COM inputs on the Meter.
2. Set the Meter rotary switch to = V .
3. Refer to Table 3-6. Apply the inputs in steps 1 through 5 and compare the Meter's response with the values shown.

Table 3-5. Frequency Counter Sensitivity and Trigger Level Tests

STEP	RANGE	AMPLITUDE (RMS)	FREQUENCY	DISPLAY READING
1	4V ac	300 mV ac	1 kHz	999.8 - 1000.2
2	4V dc	1.7V ac	1 kHz	999.8 - 1000.2
3	4V dc	1.0V ac	1 kHz	0000
4	40V dc	6.0V ac	1 kHz	999.8 - 1000.2
5	40V dc	2.0V ac	1 kHz	0000

Table 3-6. DC Voltage Test

STEP	DC INPUT VOLTAGE	DISPLAY READINGS	
		FLUKE 86	FLUKE 88
1	3.500V	3.488 to 3.512	3.493 to 3.507
2	35.00V	34.88 to 35.12	34.93 to 35.07
3	-35.00V	-34.88 to -35.12	-34.93 to -35.07
4	350.0V	348.8 to 351.2	349.3 to 350.7
5	1000V	993 to 1007	995 to 1005

3-20. Testing the DC mV Function

Perform the following procedure to verify the accuracy of dc millivolt measurements.

1. Connect the calibrator to the **V Ω →|←** and COM inputs on the Meter.
2. Set the Meter rotary switch to ⎓**mV**.
3. Apply 350.0 mV.

   For the Fluke 86, the display should read between 348.8 and 351.2 mV.

   For the Fluke 88, the display should read between 349.3 and 350.7 mV.

3-21. Testing the Ohms Function

Perform the following procedure to verify the accuracy of resistance measurements.

1. Connect the resistance calibrator to **V Ω →|←** and COM on the Meter.
2. Set the Meter rotary switch to Ω.
3. Refer to Table 3-7. Apply the inputs in steps 1 through 4 and compare the display reading with the values shown.
4. Press the RANGE button twice to enter the 400-MΩ range used for conductance tests of high resistances. Then proceed with step 5 of Table 3-7.

3-22. Testing the Diode Test Function

Perform the following procedure to check the diode test function:

1. Set the Meter rotary switch to →|←.
2. Connect the calibrator to the **V Ω →|←** and COM inputs on the Meter.

NOTE

On Fluke 5100 Series Calibrators, activate the 50Ω divider override.

3. Apply 3.000V.

   The display should show 3.000V ± 0.061V dc.

3-23. Testing the mA Functions

Perform the following procedure to verify the accuracy of mA (ac and dc) measurements:

1. Connect the calibrator to the **mA** and COM inputs on the Meter.

Table 3-7. Ohms Test

STEP	RESISTANCE	DISPLAY READINGS	
		FLUKE 86	FLUKE 88
1	190.0Ω	189.1 to 190.9	189.5 to 190.5
2	19.00 kΩ	18.91 to 19.09	18.95 to 19.05
3	1.900 MΩ	1.891 to 1.909	1.895 to 1.905
4	19.00 MΩ	18.78 to 19.22	18.78 to 19.22
5	100 MΩ	97 to 103	97 to 103

2. Set the Meter rotary switch to $\frac{mA}{A}$ ⎓.

3. Refer to Table 3-8. Apply the inputs in steps 1 and 2 and compare the display reading with the values shown.

4. Set the Meter function to $\frac{mA}{A}$ ~.

5. Apply the inputs in steps 3 through 6 and compare the display reading with the values shown.

3-24. Testing the Amp Functions

Perform the following procedure to verify the accuracy of A (ac and dc) measurements.

1. Set the calibrator output to 0 amps.

2. Set the Meter rotary switch to $\frac{mA}{A}$ ⎓.

3. Connect the calibrator to the A and COM inputs of the Meter.

4. Refer to Table 3-9. Apply the inputs in steps 1 and 2, and compare the display reading with the values shown.

5. Set the calibrator output to 0 amps, and set the Meter rotary switch to $\frac{mA}{A}$ ~.

6. Apply the inputs in steps 3 through 6 and compare the display reading with the values shown.

3-25. Testing the Inductive Pickup

To test the inductive pickup, a triangle wave from the function generator will simulate automobile spark plug signals on a loop of wire containing a 10-Ohm resistor. The pickup will be clamped to the wire and output voltage from the pickup will be monitored by an oscilloscope.

Perform the following procedure to test the inductive pickup:

1. Solder a 10-inch piece of 14 AWG wire to each end of a 10-Ohm 1% resistor.

2. Connect the other end of the 10-Ohm resistor to the terminal LOW output of the function generator. Place the other end of the 14-AWG wire to the HIGH output of the function generator. See Figure 3-4.

3. Connect a 10X scope probe from channel 2 (dc-coupled) of the oscilloscope across the 10-Ohm resistor.

4. Clamp the inductive pickup to the wire loop on the HIGH side of the resistor as shown in Figure 3-4.

   Make sure that the jaws of the inductive pickup are closed completely, and that the side of the inductive pickup that says "SPARK PLUG SIDE" points toward the HIGH output of the function generator.

5. Connect a 10X scope probe from channel 1 (dc-coupled) of the oscilloscope across the output of the inductive pickup.

6. Set up the function generator as follows:

Mod/Sweep Period s	10 ms
Mode	Single (or N Cycle)
Range	2M
Waveform	Triangle
Start Phase	-pi/2
Period	x1
Std By/Cont	Cont
600 Ohm/50 Ohm	50 Ohm
AM/FM Depth	Off
Attenuation	None
Duty Cycle	Out
DC Offset	In
Frequency	0.666 MHz

7. Set the oscilloscope for 0.5V/DIV @ 0.5 μs/DIV.

Table 3-8. Milliamp Tests

STEP	DC mA	DISPLAY READINGS	
		FLUKE 86	FLUKE 88
1	35.00 mA	34.63 to 35.37	34.70 to 35.30
2	350.0 mA	346.3 to 353.7	347.0 to 353.0
	AC mA	**FREQUENCY**	**FLUKE 86 & 88**
3	35.00 mA	60 Hz	33.85 to 36.15
4	35.00 mA	1.0 kHz	33.85 to 36.15
5	350.0 mA	60 Hz	344.2 to 355.8
6	350.0 mA	1.0 kHz	344.2 to 355.8

Table 3-9. Amp Tests

STEP	DC AMPS	DISPLAY READINGS	
		FLUKE 86	FLUKE 88
1	3500 mA	3463 to 3537	3470 to 3530
2	10.00A	9.83 to 10.17	9.85 to 10.15
	AC AMPS	**FREQUENCY**	**FLUKE 86 & 88**
3	3500 mA	60 Hz	3444 to 3558
4	3500 mA	1.0 kHz	3442 to 3558
5	10.00A	60 Hz	9.80 to 10.20
6	10.00A	1.0 kHz	9.80 to 10.20

8. Trigger the waveform on Channel 2.

   Adjust the amplitude of the function generator to produce a 3VP-P triangle wave. See Figure 3-5(A).

9. Set the oscilloscope for 1.0V/DIV @ 5.0 ms/DIV.

10. Trigger the waveform on Channel 1.

    Check that the peak voltage is greater than 6.0V and decays to less than 1.0V between pulses. See Figure 3-5(B).

11. Adjust the peak voltage to 6V using the variable voltage gain control (VAR).

12. Set the scope for 1.0 ms/DIV and trigger waveform.

13. Check the amplitude after 3.0 ms from the waveform peak, the voltage amplitude is 2.4V +0.5/-0.8 (1.6V to 2.9V). See Figure 3-5(C).

14. Set the scope for 5.0 ms/DIV and return the variable voltage gain control to the calibrated (CAL) position.

15. Turn the inductive pickup so that "SPARK PLUG SIDE" points along the wire connected to the LOW output of the function generator. Check that the waveform is less than 2V.

3-26. CALIBRATION

Calibrate the meter once a year to ensure that it performs according to specifications. Connect the calibrator to the V Ω ⊣⊢ and COM inputs on the Meter. Calibration adjustment points are identified in Figure 3-6.

Perform the following procedure to calibrate the Meter:

1. Set the source for volts dc, 0V.

2. Set the Meter rotary switch to ⎓ V. Press RANGE three times to select the 4V DC range.

3. Connect the source to the V Ω ⊣⊢ and COM inputs on the Meter.

4. Set the source for 3.500V dc output.

5. The Meter should display 3.500 ±0.001. If necessary, adjust R21 to obtain the proper display.

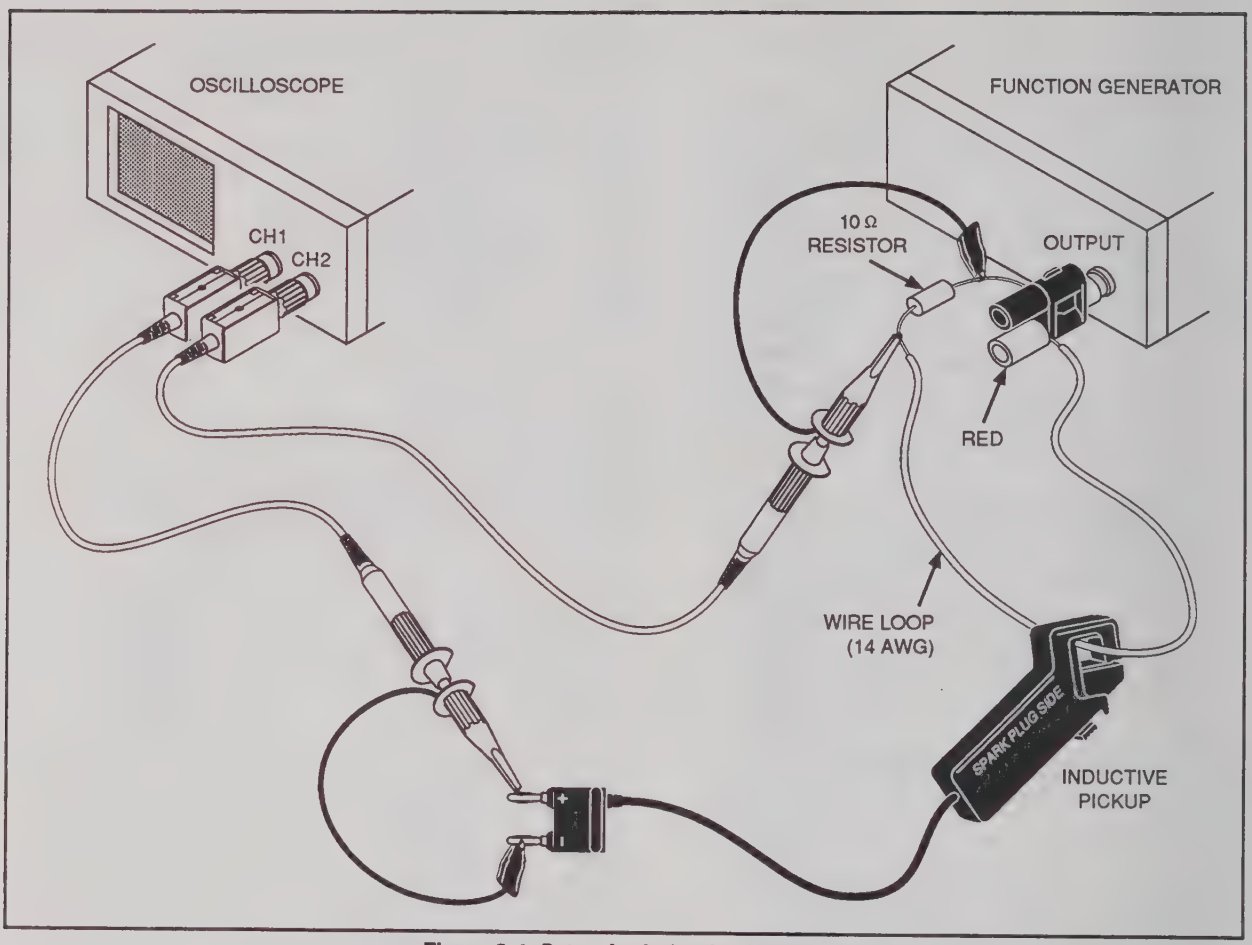


Figure 3-4. Setup for Inductive Pickup Test

6. Set the Meter rotary switch to ~V, then set the source for an output of 3.500V at 100 Hz.
7. The Meter should display 3.500 ±0.002. If necessary, adjust R34 to obtain the proper display.
8. Set the source for an output of 3.500 at 10 kHz.
9. The Meter should display 3.500 ±0.010. If necessary, adjust C2 to obtain the proper display.
10. Push RANGE once to put the unit in the 40V AC range.
11. Set the source for an output of 35V at 10 kHz.
12. The Meter should display 35.00 ±0.10. If necessary, adjust C3 to obtain the proper display.

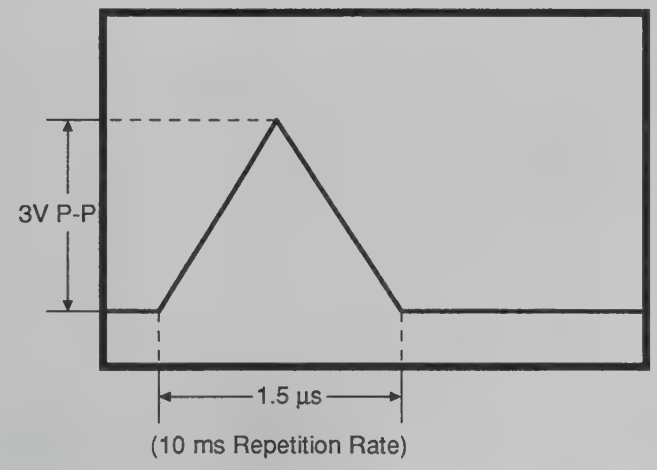
3-27. SERVICING SURFACE-MOUNT ASSEMBLIES

The Meter incorporates Surface-Mount Technology (SMT) for printed circuit assemblies. Surface-mount components are much smaller than their predecessors, with leads soldered directly to the surface of a circuit board; no plated through-holes are used. Unique servicing, troubleshooting, and repair techniques are required to support this technology.

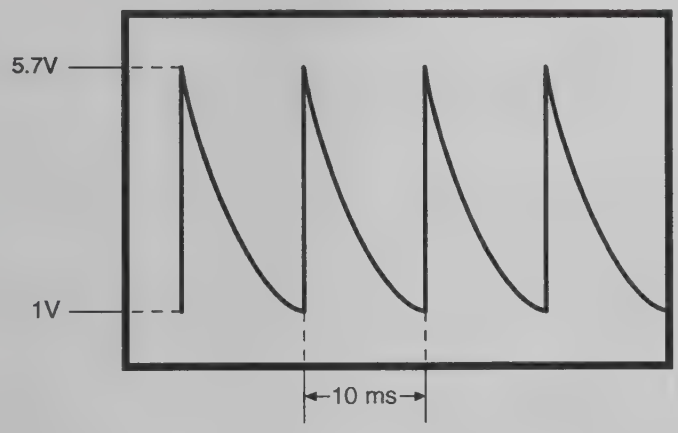
The following paragraphs introduce some SMT techniques and considerations. Technicians unfamiliar with SMT should not attempt repairs only on this information. Get the Fluke publication "Surface-Mount Technology" (Cat. No. F0119) and the "Surface-Mount Technology Service Kit" (Cat. No. A0320) for a complete discussion and demonstration of these techniques. In USA, call 1-800-526-4731 to order; Outside USA, contact your nearest Fluke/Philips service center.

Since sockets are seldom used with SMT, "shotgun" troubleshooting cannot be used. A fault should be isolated to the component level before a part is replaced. Surface-mount assemblies are probed from the component side. The special probes make contact only with the pads in front of the component leads. With the close spacing involved, ordinary test probes can easily short two adjacent pins on an SMT IC.

A. OSCILLOSCOPE DISPLAY OF TRIANGLE WAVE



B. OSCILLOSCOPE DISPLAY OF INDUCTIVE PICKUP OUTPUT



C. OSCILLOSCOPE DISPLAY OF WAVEFORM DECAY

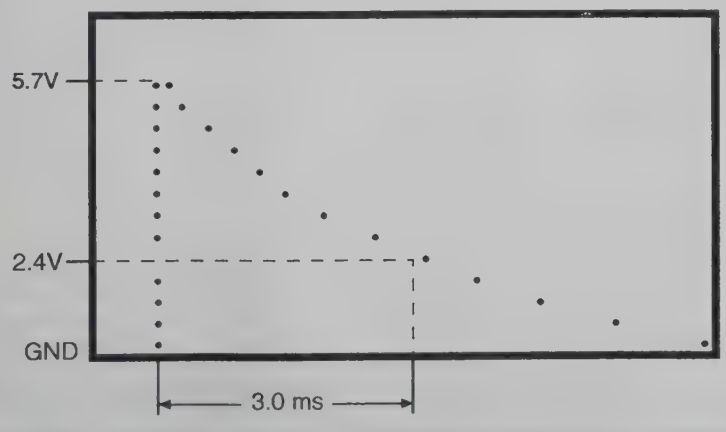


Figure 3-5. Waveform for Inductive Pickup Test

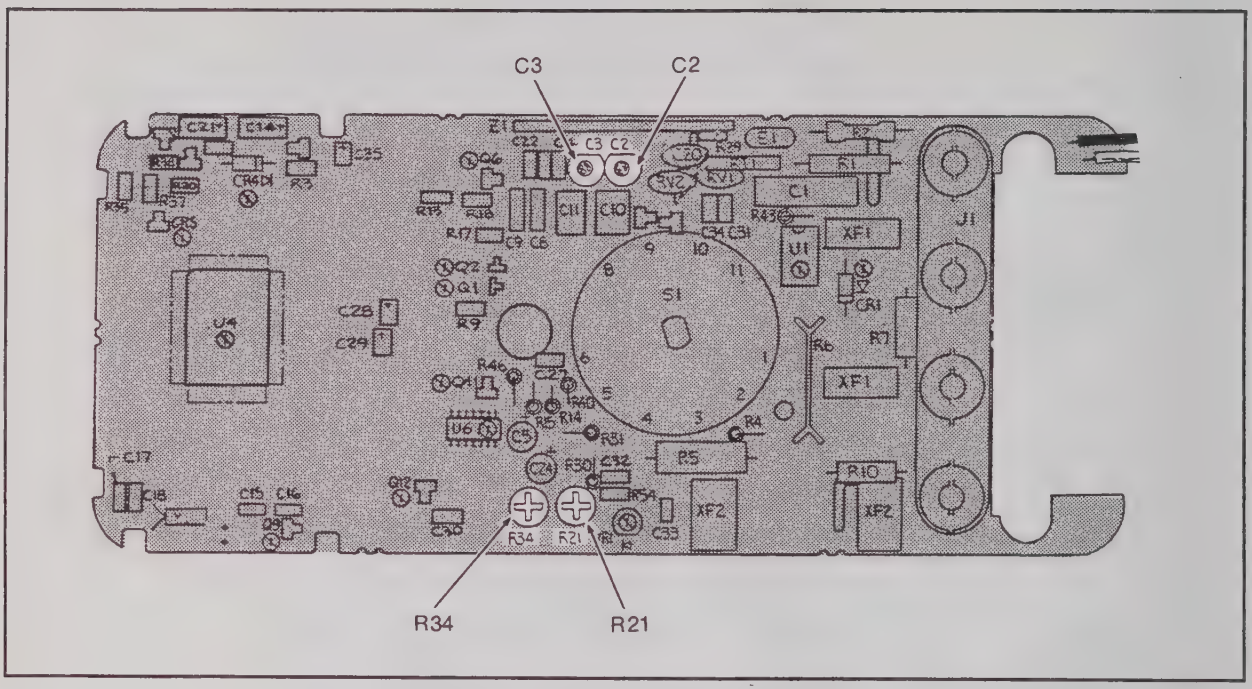


Figure 3-6. Calibration Ajustment Points

This Service Manual is a vital source for component locations and values. With limited space on the circuit board, chip component locations are seldom labeled. Figures provided in Section 4 of this manual provide this information. Also, remember that chip components are not individually labeled; keep any new or removed component in a labeled package.

Surface-mount components are removed and replaced by reflowing all the solder connections at the same time. Some special considerations follow:

- The solder tool uses regulated hot air to melt the solder; there is no direct contact between the tool and the component.
- Surface-mount assemblies require rework with wire solder rather than with solder paste. A 0.025-inch diameter wire solder, composed of 63% tin and 37% lead is recommended. A 60/40 solder is also acceptable.
- A good connection with SMT requires only enough solder to make a positive metallic contact. Too much solder causes bridging, while too little solder can cause weak or open solder joints.
- With SMT, the anchoring effect of the through-holes is missing; solder provides the only means of mechanical fastening. Therefore, the pca must be especially clean to ensure a strong connection. An oxidized pca pad causes the solder to wick up the component lead, leaving little solder on the pad itself.

3-28. TROUBLESHOOTING THE POWER SUPPLY

If the Meter fails, check the battery and fuses and replace as needed. If problems still persist, review the operating instructions in the Users Manual. If these measures suggest a fault with the Meter, consult the TROUBLESHOOTING THE POWER SUPPLY procedures that follow and the signal flow diagrams in Section 5.

The two regulator circuits are interrelated; a malfunction in either the common regulator or the VDD regulator may cause a problem in the other. Refer to Tables 3-10 and 3-11 for descriptions of power supply components and voltage levels, respectively. To isolate the problem regulator circuit, disconnect the battery, and drive VDD - VSS = 6.2V with a power supply. This procedure tests the common regulator independently of the VDD regulator.

Now check for VDGND - VSS = -3.2V ±0.3V. If this test is successful, the problem lies with the VDD regulator; refer to "VDD (Series) Regulator Troubleshooting" later in this section. If this test is not successful, the problem lies with the common regulator; continue with the "Common (Shunt) Regulator Troubleshooting" below.

Note that if the common regulator works or has been repaired, check both supplies with the 9V battery supply.

Table 3-10. Functional Description of Power Supply Components

COMPONENT	FUNCTION
Q3	Vdd Regulator series regulator device
Q8	Power on/off device
Q10	Power supply startup device. Q10 provides Q8 base startup current. Q10 is always off during meter operation.
CR5	CR5 is in the power supply series loop, allowing for generation of Vbt=+3.6V for diode test.
VR1	VR1 provides the system reference voltage. It is used for the a/d converter reference and as a reference for both power supply regulators.
C14	VDD regulator compensation and bypass.
C21	Common regulator compensation and bypass.
C35	Battery and CR5 bypass.
C32	Q8 gate bypass.
R24, R25	VDD regulator voltage-sensing resistors.
R37, R38	Common regulator voltage-sensing resistors.
R44	Supplies bias current to VR1.
R54	Q8 gate pull-up resistor.

Table 3-11. Voltage Levels

SIGNALS	LEVELS
VDD	3.0 ±0.3
VSS	3.2 ±0.3
VBT+	3.5 ±0.3
VBT-	5.5 (battery at full 9V charge) 3.0 (battery at low charge of 6.5V)
REFH	1.235 ±0.012
PS0	1.235 ± 0.15
PS1	0 ±0.15
AP6	-0.5 to -0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to .85 (referenced from VSS)

3-29. Common (Shunt) Regulator Troubleshooting

Refer to Figure 3-7 for a simplified diagram of the common regulator. To troubleshoot the common regulator, connect the power supply so that VDD, VSS, and DGND (digital ground) are supplied from an external power supply. This procedure overdrives the large on-chip shunt transistors; the bias current from the power supply ranges from 10 mA to 100 mA. Make the following tests:

1. Check for +1.235V ±20 mV (VREFH) at the cathode of VR1. If VREFH is not correct, carefully check VR1, R19, R20, and R44 and the traces to these parts. If VREFH is still incorrect, U4 is bad.

2. If VREFH is correct, measure the voltage at U4 pin 6 (PS1). If VPS1 is not equal to 0V ±0.15V, check R37 and R38 and their associated traces. If VPS1 is still at an incorrect voltage, U4 is bad.

3. A DGND and VSS current much larger than 100 mA may indicate a problem with Q12 (VDGND-to-VSS quick turn-off clamp) or its base drive signal from U6. The Q12 clamp is off when the Meter is on and on when the Meter is off.

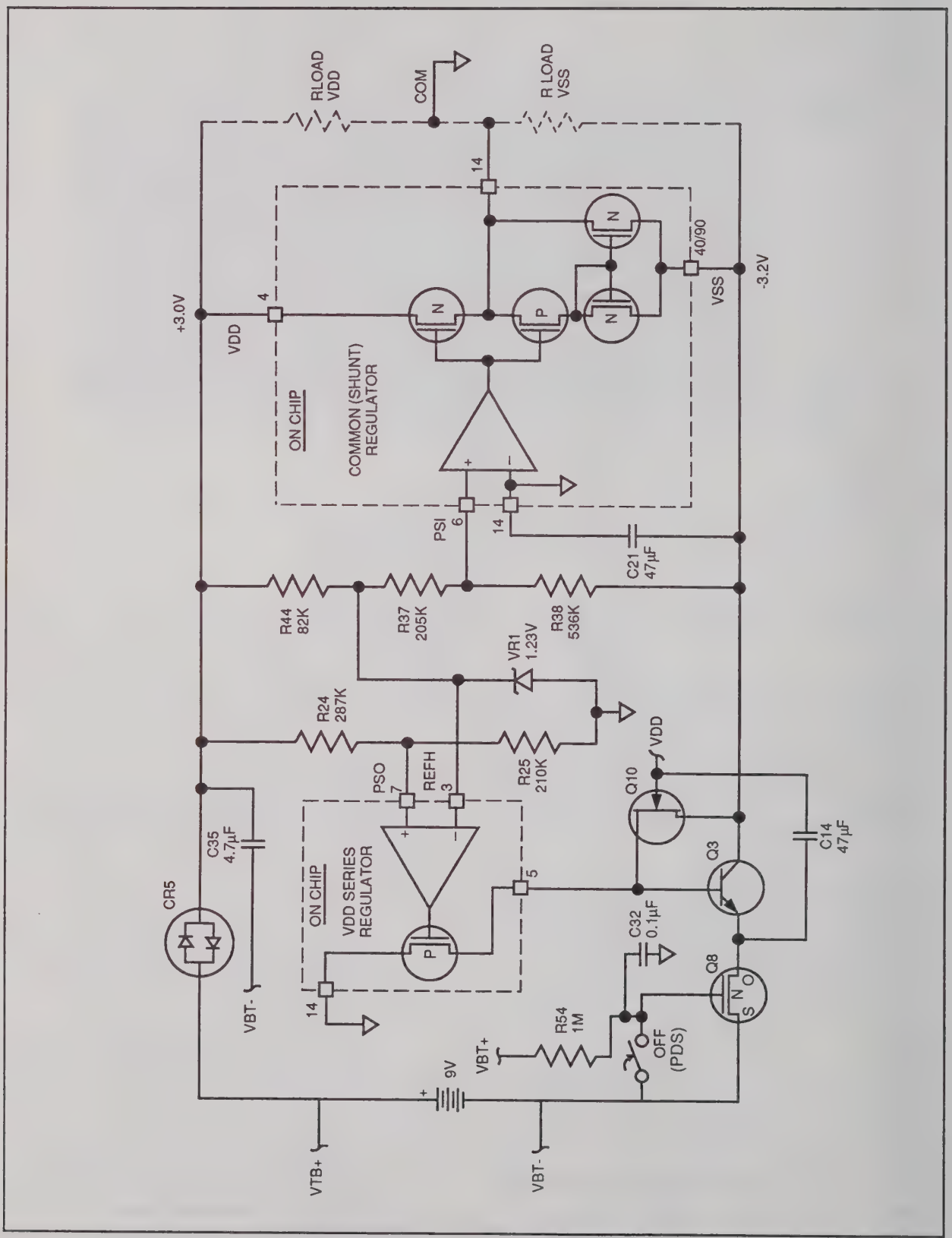


Figure 3-7. Simplified Power Supply Schematic

4. Check the bias generator circuit. With the exception of resistor R35 (620 kΩ), the bias generator (which sets the bias level for all U4 analog circuitry) is internal to U4. A problem with this circuit could cause the on-chip power supply op amps not to work. Measure the dc voltage between U4 pin 8 (Vbias) and DGND. If -0.2V < Vbias > +0.2V the bias generator is okay. If Vbias is not correct, check R35. If Vbias is still wrong, replace U4.

5. Measure the ac voltage between VDGND and VSS. If the voltage is greater than 10 mV ac, check C21. (An open C21 causes common regulator instability.) The dc level may also be incorrect.

6. If the common regulator still does not work, circuitry internal to U4 is bad. Replace U4.

3-30. VDD (Series) Regulator Troubleshooting

If a problem still exists after troubleshooting the common regulator, toubleshoot the VDD regulator. Often, a short or sneak current path causes power supply problems. Refer to Figure 3-7 for a simplified diagram of the VDD (Series) Regulator. Make the following tests:

1. Measure the dc operating current from the 9V battery. If it is greater than 1.2, a sneak current path exists. A sneak current path can be very difficult to find.

2. First, visually check for both solder bridges on U4 pins and other circuit board shorts.

Isolate the current path at the negative battery terminal (VBT-). The components connected to VBT- are C35, CR4, R56, U6, Q8, and the rotary switch "fingers". Remove these parts one at a time (except Q8). Measure I(bat) after each removal to isolate the problem.

1. If the excess battery current stops after removing R56, either R56, R57, Q9, or Q11 may be bad. If one of these four parts is bad a problem may not be noticed until U6 is removed.

2. If the extra current is still present with all parts except Q8 removed, remove Q10 and check for excess battery current. If I(bat) is now correct, Q10 is bad. If I(bat) is still excessive, U4 is probably at fault.

If the power supply is not working but battery current is normal, perform the following tests.

1. With the 9V battery attached, cycle the unit off and on. If both supplies are less than 1.0V, a problem probably exists with the on/off circuit. Check Q8, R54, and C32.

2. Check the rotary switch wiper contacts; verify that the Q8 gate voltage is close to VBT+.

3. If VDD - VSS is low, a problem may exist with startup device Q10. Check Q10 by momentarily connecting VSS to VBT-. If both VSS and VBT- now start up and operate correctly, check Q10 for an open.

4. Measure the ac voltage between VDD and VSS. An unstable VDD regulator can be caused by an open C14. If the voltage is greater than 10 mV ac, check C14. The dc level may also be incorrect.

For a final check of U4, remove the battery and supply VDD = +3.0V, VDGND = 0, and VSS = -3.2V from an external power supply. Measure the voltage at U4 pin 7 (VPS0). If it does not equal 1.235V ±0.15V, check R24 and R25 carefully. If VPS0 is still incorrect, U4 is bad.

3-31. TROUBLESHOOTING A FUNCTION SELECTION MALFUNCTION

NOTE

The following information refers to Polymer Thick Film (PTF). For more information refer to "Function-Encoding Potentiometer" in Section 2 of this manual.

Problems related to rotary switch function selection usually manifest themselves in one of two ways:

1. The Meter will not turn off when the rotary switch is in the OFF position.

OR

2. The Meter does not enter the function indicated by the rotary switch setting.

Both of these problems can be intermittent and can be caused by different malfunctions.

3-32. Meter Does Not Turn Off (Problem 1)

If the Meter does not turn off when the rotary switch is in the OFF position, the wiper contacts are probably not making contact with the PTF sections. This may not allow the Power Down Signal (PDS) line to be pulled low by VBT-. Check the wiper contacts for good spring tension against the PTF surface. Make sure that the PTF

surface and spring contacts are clean. If they are not, clean them with isopropyl alcohol. To get to the wiper contacts, perform the procedures under "Disassembling the Case" and "Removing and Reinstalling the Circuit Assembly" previously described in Section 3.

This problem could be unrelated to the PTF, in which case a power supply component, such as Q8, may be at fault. Refer to TROUBLESHOOTING THE POWER SUPPLY earlier in Section 3.

3-33. Meter Enters Wrong Function (Problem 2)

If the Meter does not enter the function indicated by the rotary switch selection, the most probable cause is an out-of-tolerance PTF resistor section. This can be checked by performing the procedure under "Function Selection (Rotary Switch) Test" given earlier in Section 3. If the display reading is outside the tolerances given, the PTF resistor section is bad, and the pca must be replaced. (This assumes that the PTF wiper contacts are good. If the wiper contacts are not making proper contact with the PTF sections, the Meter can also select the wrong function. See "Meter Does Not Turn Off", above. However, poor contact is more likely to cause an intermittent rather than a total failure.)

If the Meter powers up in ac mV and will not change functions, the problem is caused by the inability of the a/d converter to measure, NOT BY THE PTF. The a/d converter must do a ratio measurement of the PTF resistor in order to change functions. U4 or one of its peripherals can cause this problem.

Section 4
List of Replaceable Parts

ASSEMBLY NAME	TABLE NO.	TABLE PAGE	FIGURE NO.	FIGURE PAGE
Fluke 86 Final Assembly	4-1	4-3	4-1	4-4
Fluke 86 A1 Main PCA	4-2	4-6	4-2	4-7
Fluke 88 Final Assembly	4-3	4-8	4-3	4-9
Fluke 88 A1 Main PCA	4-4	4-11	4-4	4-12

4-1. INTRODUCTION

This section contains an illustrated list of replaceable parts for the 86 and 88 Automotive Meters. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge.
- Description
- Fluke stock number
- Manufacturers supply code
- Manufacturers part number or generic type
- Total quantity
- Any special notes (i.e., factory-selected part)

CAUTION

A * symbol indicates a device that may be damaged by static discharge.

4-2. HOW TO OBTAIN PARTS

Electrical components may be ordered directly from the manufacturer by using the manufacturers part number, or from the Fluke Corporation and its authorized representatives by using the part number under the heading FLUKE STOCK NO. A list of manufacturers supply codes is provided at the end of this section. Parts price information is available from the Fluke Corporation or its representatives.

In the event that the part ordered has been replaced by a new or improved part, the replacement will be accompanied by a explanatory note and installation instructions, if necessary.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- Fluke stock number
- Description (as given under the DESCRIPTION heading)
- Quantity
- Reference designator
- Part number and revision level of the pca containing the part.
- Instrument model and serial number

4-3. MANUAL STATUS INFORMATION

The Manual Status Information table that precedes the parts list defines the assembly revision levels that are documented in the manual. Revision levels are printed on the component side of each pca.

4-4. NEWER INSTRUMENTS

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pca. These changes are documented on a supplemental change/errata sheet which, when applicable, is included with the manual.

4-5. SERVICE CENTERS

A list of service centers is located at the end of this section.

NOTE

This instrument may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke service center for recycling information.

WARNING

THIS INSTRUMENT CONTAINS A FUSIBLE RESISTOR (PN 832550). TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.

MANUAL STATUS INFORMATION

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	X = The PCA revision levels documented in this manual.																			
			–	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P			
86-A1	Main PCA	890306								X												
88-A1	Main PCA	890314									X											

Table 4-1. Fluke 86 Final Assembly
(See Figure 4-1.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
A 1	*	MAIN PCA			NON PROCURABLE	1	
BT 1		BATTERY,PRIMARY,ALKALINE,9V,0-200MA	614487	7X634	MN1604	1	
E 1		CONTACT,PTF	822676	89536	822676	1	
E 2		CONTACT,ANNUNCIATOR	822791	89536	822791	1	
F 1		FUSE,.406X1.375,1A,600V,FAST	830828	71400	BBS-1	1	
F 2		FUSE,.406X1.5, 15A, 600V, FAST	820829	71400	KTK-15	1	
H 1		SCREW,PH,P,THD FORM,STL,4-14,.562	832220	89536	832220	1	
H 2- 4		SCREW,PH,P,THD FORM,STL,5-14,.750	832246	89536	832246	3	
J 1, 2		CONN,ELASTOMERIC,LCD TO PWB,1.590 L	817460	0K392	817460	2	
MP 1		MASK,LCD (PAD XFER)	930305	89536	930305	1	
MP 2		SHIELD,TOP	824516	89536	824516	1	
MP 3		SHAFT,SWITCH	822635	89536	822635	1	
MP 4		SHIELD,BOTTOM	824524	89536	824524	1	
MP 5		CASE TOP (PAD XFER)	880802	89536	880802	1	
MP 6		CASE & GASKET ASSY, BOTTOM	919485	89536	919485	1	
MP 8		KNOB,SWITCH (PAD XFER)	880815	89536	880815	1	
MP 9		SPRING,DETENT	822643	89536	822643	1	
MP 10, 11		FOOT,NON SKID	824466	89536	824466	2	
MP 13		SHOCK ABSORBER	828541	89536	828541	1	
MP 14		O-RING,SYN RUBBER,1.670 ID,0.047 WIDE	831933	2K160	5-143N674-70	1	
MP 15		HOLSTER & FLEXSTAND ASSY YELLOW	822809	89536	822809	1	
MP 16		ACCESSORY PACK,FLUKE-86	890363	89536	890363	1	1
MP 17		DECAL,CARRYING CASE	880828	89536	880828	1	
MP 18		CASE,MOLDED,TRANSIT,86/87/88	875661	53718	875661	1	
MP 21		LABEL,PAPER,2.00,3.00	885939	22670	80666	1	
MP 22		SLIP COVER	880836	89536	880836	1	
MP 23		BOX ACCESS,INSERT,27.00,4.00,13.25	876776	89536	876776	1	
MP 24		BOX,SHIP,4 PANEL,27.00,13.25,18.50	876110	89536	876110	1	
R 60	*	RESISTOR,SELECTED RC CLOCK	871298	89536	871298	1	
S 2		SWITCHPAD, MOMENTARY	879056	89536	879056	1	
TM 1		MANUAL, FLUKE 88 SERVICE	880906	89536	880906	0	2
TM 5		MANUAL, FLUKE 88 OPERATOR, ENGLISH	880914	89536	880914	1	
TM 6		MANUAL, FLUKE 88 OPERATOR, INTL	880919	89536	880919	1	
U 5		LCD,4.5 DIGIT,BAR GRAPH,MULTIPLEXED	868088	62786	LS424E	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:

1. ACCESSORY PACK INCLUDES THE FOLLOWING PARTS:

PICK-UP,INDUCTIVE,TESTED	890355
ALLIGATOR CLIP RED	738120
ALLIGATOR CLIP BLACK	738047
TEST LEADS	855742

2. AVAILABLE THROUGH PARTS DEPARTMENT ONLY.

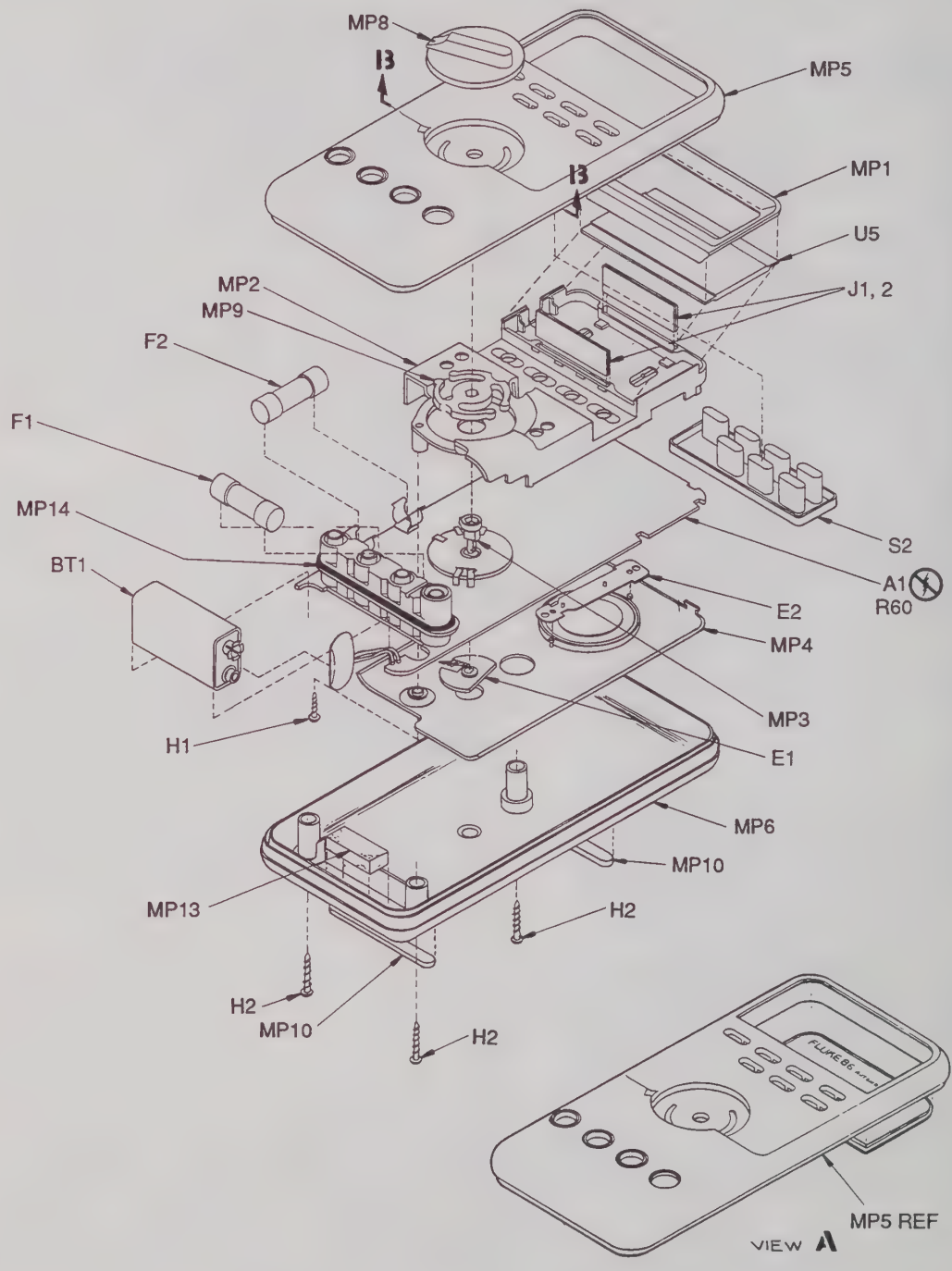


Figure 4-1. Fluke 86 Final Assembly

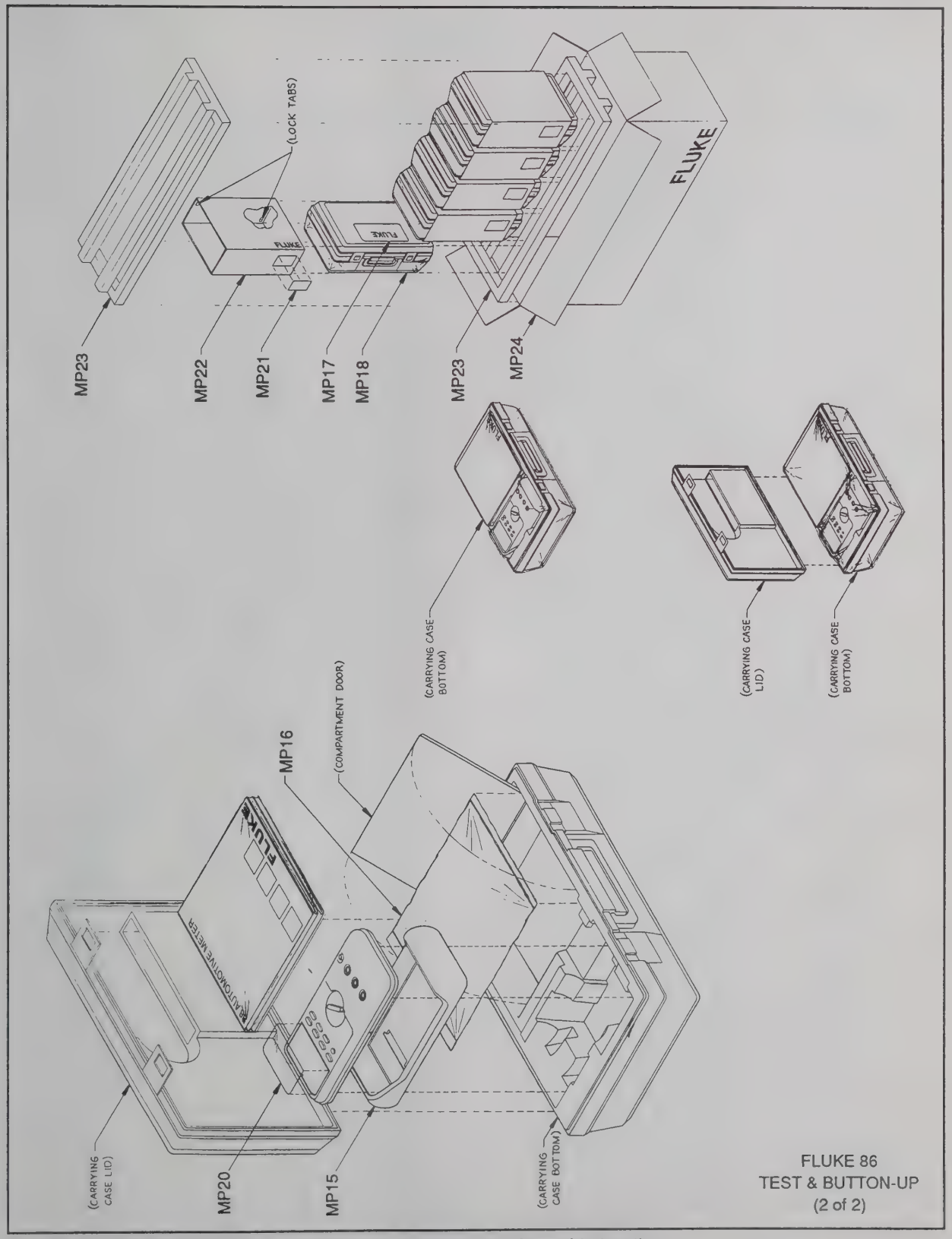


Figure 4-1. Fluke 86 Final Assembly (cont)

Table 4-2. Fluke 86 A1 Main PCA
(See Figure 4-2.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
C 1		CAP,POLYES,0.01UF,+-10%,1000V	822361	68919	MKS4103K1000	1	
C 2		CAP,VAR,3-11PF,100V,CER	641712	51406	TZ03T110FR174	1	
C 3		CAP,VAR,9-90PF,50V,CER	643130	51406	TZ03R900FR174	1	
C 4		CAP,CER,430PF,+-2%,50V,C0G,1206	851816	04222	12065A431GATBA	1	
C 5		CAP,TA,15UF,+-20%,6.3V	807636	56289	199D156X06R3BG2	1	
C 8, 9		CAP,POLYCA,0.027UF,+-10%,63V	720979	68919	MKC2273K63	2	
C 10		CAP,POLYES,0.47UF,+-10%,50V	697409	37942	185-2-474K50AA	1	
C 11		CAP,POLYPR,0.022UF,+-10%,63V	821579	68919	MKP20223K63V	1	
C 14, 21		CAP,TA,47UF,+-20%,10V,7343	867580	56289	293D476X0010D2T or W	2	
C 15, 16, 32		CAP,CER,0.1UF,+-10%,25V,X7R,1206	747287	04222	12065C104KATBA	3	
C 17, 18		CAP,CER,22PF,+-10%,50V,C0G,1206	740563	04222	12065A220KATBA	2	
C 20		CAP,CER,5.6PF,+-0.25PF,1500V,C0H	851811	91984	6010C0H5R6C1.5KVT14	1	
C 22		CAP,CER,1000PF,+-10%,50V,C0G,1206	747378	04222	12065A101KATBA	1	
C 24		CAP,TA,10UF,+-20%,10V	714766	56289	199D106X0010BE2	1	
C 27		CAP,CER,130PF,+-10%,50V,C0G,1206	911227	04222	12065A131KATBA	1	
C 28, 29		CAP,TA,0.47UF,+-20%,35V,3528	867259	56289	293D474X0035B2T or W	2	
C 30		CAP,CER,220PF,+-10%,50V,C0G,1206	758078	04222	12065A221KATBA	1	
C 31, 33, 34		CAP,CER,0.01UF,+-10%,50V,X7R,1206	747261	04222	12061C103KATBA	3	
C 35, 38		CAP,TA,4.7UF,+-20%,10V,3528	867262	56289	293D475X0010B2T or W	2	
C 36		CAP,CER,68PF,+-10%,50V,C0G,1206	853861	04222	12065A680KATBA	1	
C 39		CAP,CER,150PF,+/-5%,50V,C0G,0805	866533	04222	08055A151JATMA	1	
CR 1, 4		DIODE,SI,1K PIV,1.0 AMP	707075	04713	1N4007	2	
CR 5, 7, 8	*	DIODE,SI,BV=70.0V,IO=50MA,DUAL,SOT23	742320	25403	BAV99	3	
E 1		SURGE PROTECTOR,1500V,+-20%	655134	91984	100T1	1	
J 1		INPUT RCPT ASSY	826214	89536	826214	1	
Q 1, 2, 6	*	TRANSISTOR,SI,NPN,SELECT IEBO,SOT-23	821637	04713	SMBT1388L	3	
Q 3, 9, 12	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,SOT-23	742676	04713	MMBT3904L	3	
Q 8	*	TRANSISTOR,SI,N-DMOS FET,SOT23	830851	17856	SSTVNS009	1	
Q 10	*	TRANSISTOR,SI,P-CHAN,SOT-23	832477	17856	SST175	1	
Q 11	*	TRANSISTOR,SI,PNP,SMALL SIGNAL,SOT-23	742684	04713	MMBT3906L	1	
R 1		RES,MF,1K,+-1%,100PPM,FLMPRF,FUSIBLE	832550	91637	CMF-65-69 1001F T-1,R36	1	1
R 2	*	RES,CERM,909K,+-1%,2W,100PPM	831594	23237	GS-3-909K-1%	1	
R 3	*	RES,CERM,1.5K,+-5%,.125W,200PPM,1206	746438	91637	CRCW1206-1501JB02	1	
R 4, 46		RES JUMPER,0.02,0.25W	682575	91637	FRJ-55	2	
R 5		RES,WW,.991,+-.1%,2.5W	821645	91637	RS-2C 9913F	1	
R 6		RES,WW,.010,+-.1%,1W,100PPM	807305	05347	Q426BR010B	1	
R 7, 10	*	RES,CERM,1M,+-5%,1W,200PPM	912589	89536	912589	2	
R 8	*	RES,CERM,0,+.05 MAX,.125W,1206	810747	91637	CRCW1206-0000FT	1	
R 9, 13, 29	*	RES,CERM,100K,+-5%,.125W,200PPM,1206	740548	91637	CRCW1206-1003JB02	3	
R 11, 48	*	RES,CERM,10M,+-5%,.125W,300PPM,1206	783274	91637	CRCW1206-1005JB02	2	
R 12, 61- 66	*	RES,CERM,10K,+-5%,.125W,200PPM,1206	746610	91637	CRCW1206-1002JB02	7	
R 14		RES,MF,10K,+-0.1%,0.125W,100PPM	658955	59124	MF50D1002B	1	
R 15		RES,MF,90K,+-0.1%,0.125W,100PPM	658906	59124	MF50D9002B	1	
R 17, 18, 42,	*	RES,CERM,1M,+-5%,.125W,200PPM,1206	746826	91637	CRCW1206-1004JB02	4	
R 54	*		746826				
R 19	*	RES,CERM,56.2K,+-1%,.125W,100PPM,1206	831305	91637	CRCW1206-5622FB02	1	
R 20, 37	*	RES,CERM,205K,+-1%,.125W,100PPM,1206	769836	91637	CRCW1206-2053FB02	2	
R 21		RES,VAR,CERM,100K,+-20%,.3W	649897	51406	RVG-0707-V-100-3-104M	1	
R 24	*	RES,CERM,324K,+-1%,.125W,100PPM,1206	911243	91637	CRCW1206-3243FB	1	
R 25	*	RES,CERM,210K,+-1%,.125W,100PPM,1206	821660	91637	CRCW1206-2103FB02	1	
R 30		RES,MF,20K,+-0.25%,0.125W,50PPM	715029	59124	MF50C2002C	1	
R 31, 40		RES,MF,22.6K,+-0.25%,0.125W,50PPM	715011	59124	MF50C2262C	2	
R 34		RES,VAR,CERM,1K,+-20%,.3W	831420	51406	RVG-0707-V-100-3-102M	1	
R 35	*	RES,CERM,665K,+-1%,.125W,100PPM,1206	867460	89536	867460	1	
R 38	*	RES,CERM,536K,+-1%,.125W,100PPM,1206	845420	91637	CRCW1206-5363FB	1	
R 43		RES,MF,1K,+-0.1%,0.125W,100PPM	821694	59124	MF50D1001B	1	
R 44	*	RES,CERM,82K,+-5%,.125W,200PPM,1206	811794	91637	CRCW1206-8202JB02	1	
R 56, 57	*	RES,CERM,22K,+-5%,.125W,200PPM,1206	746651	91637	CRCW1206-2202JB02	2	
R 58	*	RES,CERM,120K,+-5%,.125W,200PPM,1206	746719	91637	CRCW1206-1203JB02	1	
R 59	*	RES,CERM,510,+-5%,.125W,200PPM,1206	746388	91637	CRCW1206-5100JB02	1	
R 67	*	RES,CERM,10K,+/-5%,.125W,200PPM,1206	746610	91637	CRCW1206-1002JB02	1	
RT 1		THERMISTOR,RECT,POS,1.5K,+-30%,25 C	822015	54583	911P84E152NU13	1	
RV 1, 2		VARISTOR,910,+-10%,1.0MA	876193	34371	V910LSX1399	2	
S 1		SWITCH,ROTARY	819334	89536	819334	1	
U 1		DIODE,SI,RECT,BRIDGE,BV=50V,IO=1A	418582	14936	DF01M	1	
U 4		SMX2 AUTOMOTIVE IC	921614	89536	921614	1	
U 6	*	IC,CMOS,HEX INVERTER,SOIC	838375	27014	MM5669UBM	1	
VR 1	*	IC, 1.23V,150 PPM T.C.,BANDGAP V. REF	634451	27014	LM385Z-1.2D262	1	
XBT 1		CONNECTOR,BATTERY	825976	89536	825976	1	
XF 1		CONTACT,600V,FUSE	659524	89536	659524	1	
XF 2		600 VOLT FUSE CONTACT	707190	89536	707190	1	
Y 1		CRYSTAL,131.072KHZ,0.003%,3X8MM	831453	0ED74	IT6253G20	1	
Z 1		RES NET THK FILM TESTED	828152	89536	828152	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:

1. THIS IS A FUSIBLE RESISTOR. TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.

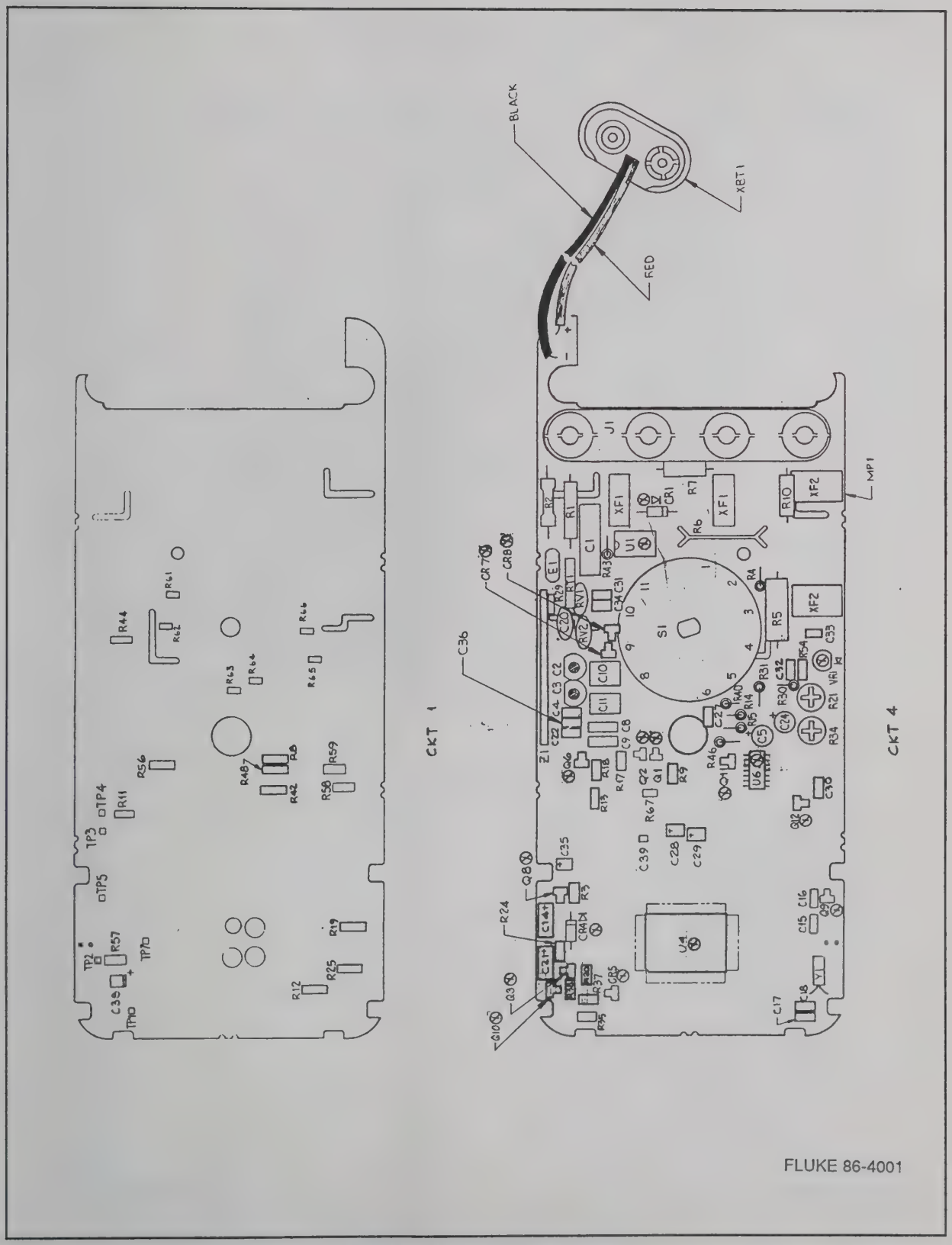


Figure 4-2. Fluke 86 A1 Main PCA

Table 4-3. Fluke 88 Final Assembly
(See Figure 4-3.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
A 1	*	MAIN PCA			NON PROCURABLE	1	
BT 1		BATTERY,PRIMARY,ALKALINE,9V,0-200MA	614487	7X634	MN1604	1	
CR 6		BACKLIGHT	819342	89536	819342	1	
E 1		CONTACT,PTF	822676	89536	822676	1	
E 2		CONTACT,ANNUNCIATOR	822791	89536	822791	1	
F 1		FUSE,.406X1.375,1A,600V,FAST	830828	71400	BBS-1	1	
F 2		FUSE,.406X1.5, 15A, 600V, FAST	820829	71400	KTK-15	1	
H 1		SCREW,PH,P,THD FORM,STL,4-14,.562	832220	89536	832220	1	
H 2- 4		SCREW,PH,P,THD FORM,STL,5-14,.750	832246	89536	832246	3	
J 1, 2		CONN,ELASTOMERIC,LCD TO PWB,1.590 L	817460	0K392	817460	2	
MP 1		MASK,LCD (PAD XFER)	930300	89536	930300	1	
MP 2		SHIELD,TOP	824516	89536	824516	1	
MP 3		SHAFT,SWITCH	822635	89536	822635	1	
MP 4		SHIELD,BOTTOM	824524	89536	824524	1	
MP 5		CASE TOP (PAD XFER)	880799	89536	880799	1	
MP 6		CASE & GASKET ASSY, BOTTOM	919493	89536	919493	1	
MP 8		KNOB,SWITCH (PAD XFER)	880815	89536	880815	1	
MP 9		SPRING,DETENT	822643	89536	822643	1	
MP 10		FOOT,NON SKID	824466	89536	824466	2	
MP 13		SHOCK ABSORBER	828541	89536	828541	1	
MP 14		O-RING,SYN RUBBER,1.670 ID,0.047 WIDE	831933	2K160	5-143N674-70	1	
MP 15		HOLSTER & FLEXSTAND ASSY YELLOW	822809	89536	822809	1	
MP 16		ACCESSORY PACK,FLUKE-88	890368	89536	890368	1	1
MP 17		DECAL,CARRYING CASE	880828	89536	880828	1	
MP 18		CASE,MOLDED,TRANSIT,86/87/88	875661	53718	875661	1	
MP 22		LABEL,PAPER,2.00,3.00	885939	22670	80666	1	
MP 23		SLIP COVER	880831	89536	880831	1	
MP 24		BOX ACCESS,INSERT,27.00,4.00,13.25	876776	89536	876776	1	
MP 30		BOX,SHIP,4 PANEL,27.00,13.25,18.50	876110	89536	876110	1	
R 60	*	RESISTOR,SELECTED RC CLOCK	871298	89536	871298	1	
S 2		SWITCHPAD, MOMENTARY	879051	89536	879051	1	
TM 1		MANUAL, FLUKE 88 SERVICE	880906	89536	880906	0	2
TM 5		MANUAL, FLUKE 88 OPERATOR, ENGLISH	880914	89536	880914	1	
TM 6		MANUAL, FLUKE 88 OPERATOR, INTL	880919	89536	880919	1	
U 5		LCD,4.5 DIGIT,BAR GRAPH,MULTIPLEXED	868088	62786	LS424E	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:

1. ACCESSORY PACK, INCLUDES THE FOLLOWING PARTS:

PICK-UP, INDUCTIVE,TESTED	890355
CLIP,ALLIGATOR,BANANA,INSUL,RED	927749
CLIP,ALLIGATOR,BANANA,INSUL,BLK	927756
PROBE,TEST,BANANA JACK,RED	927777
PROBE,TEST,BANANA JACK,BLK	927772
TEST LEAD,SI,R/A STRT,BANANA,RED	927798
TEST LEAD,SI,R/A STRT,BANANA,BLK	927793

2. AVAILABLE THROUGH PARTS DEPARTMENT ONLY.

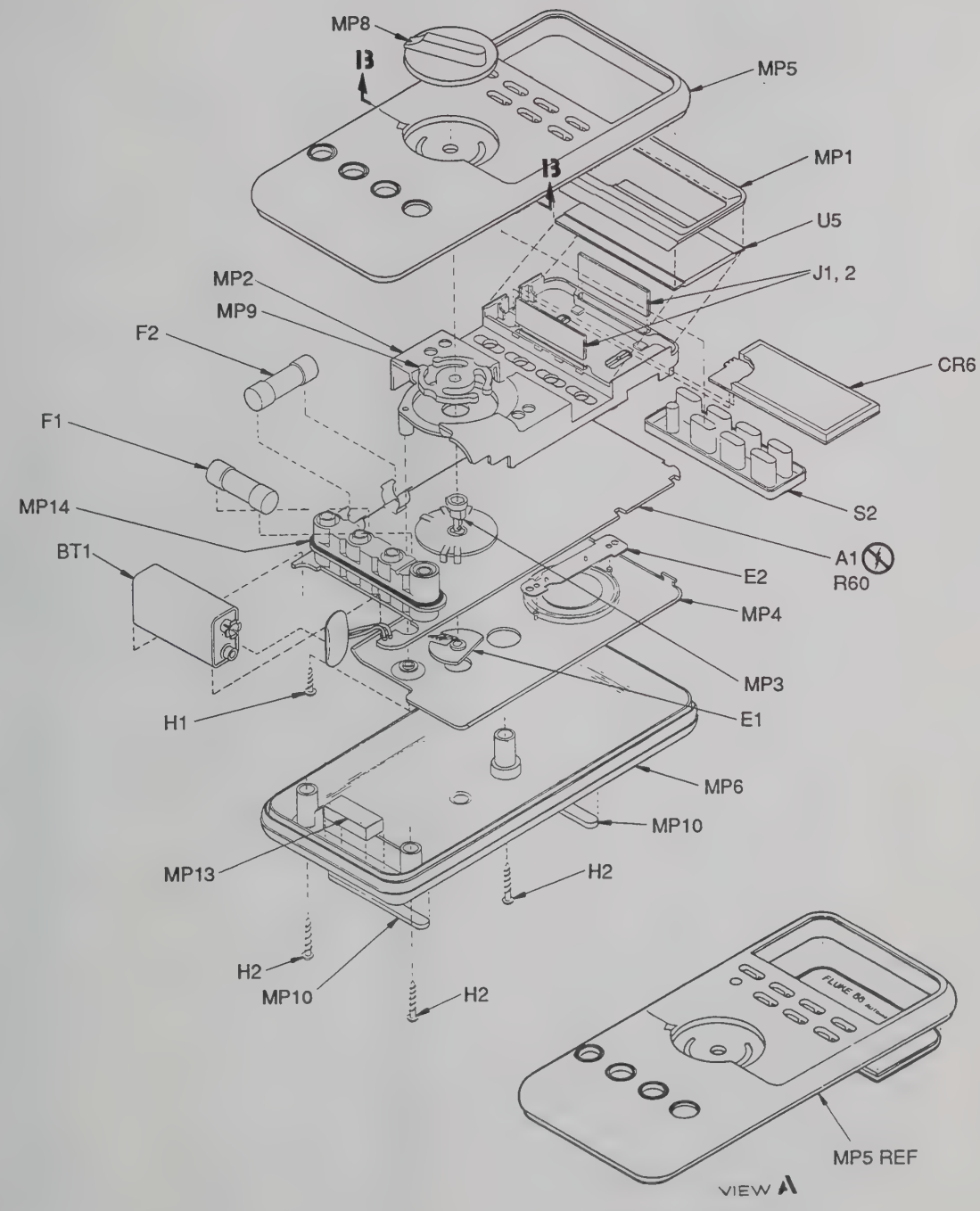


Figure 4-3. Fluke 88 Final Assembly

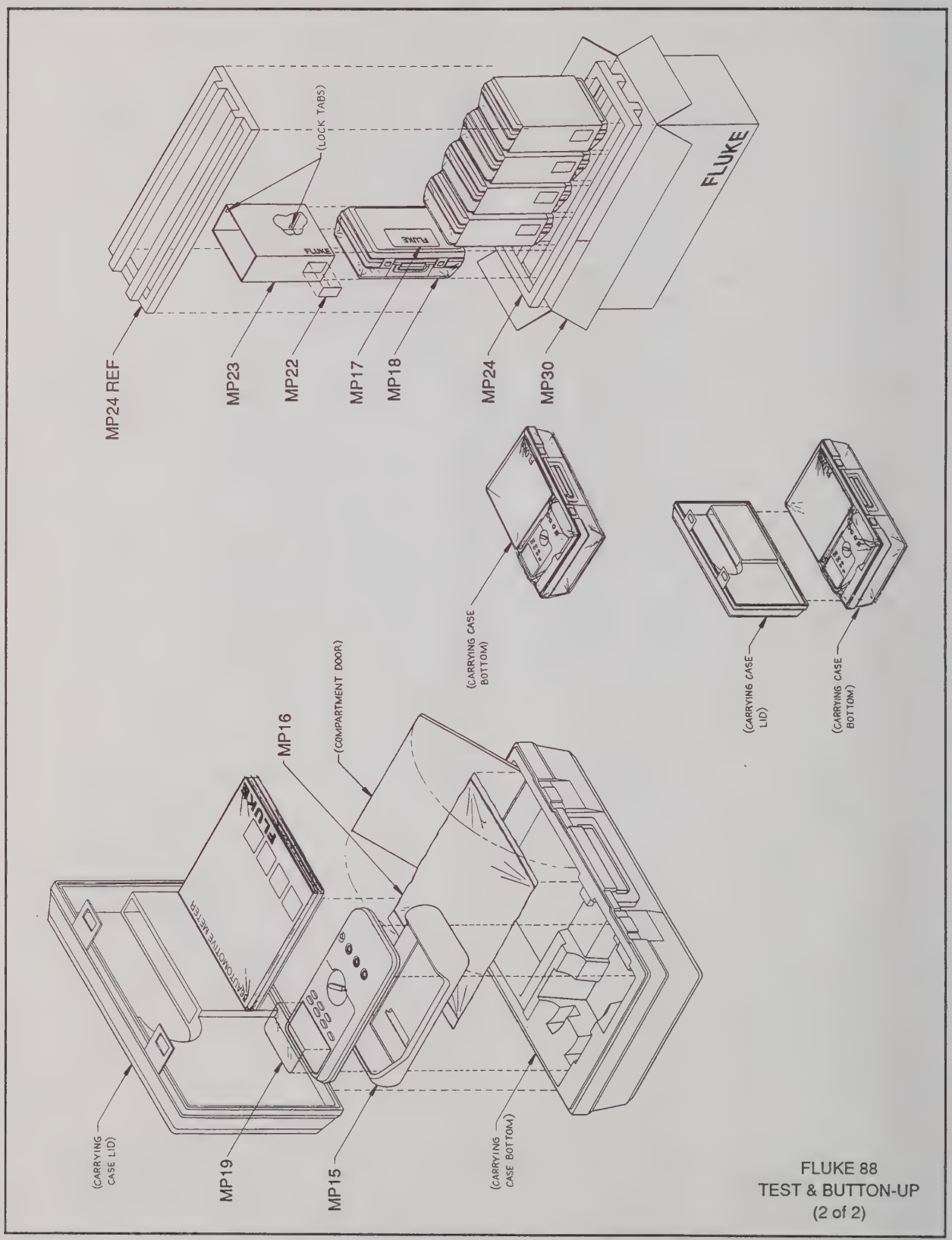


Figure 4-3. Fluke 88 Final Assembly (cont)

Table 4-4. Fluke 88 A1 Main PCA
(See Figure 4-4.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	-----------DESCRIPTION-----------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOT -E-
C 1		CAP,POLYES,0.01UF,+-10%,1000V	822361	68919	MKS4103K1000	1	
C 2		CAP,VAR,3-11PF,100V,CER	641712	51406	TZ03T110FR174	1	
C 3		CAP,VAR,9-90PF,50V,CER	643130	51406	TZ03R900FR174	1	
C 4		CAP,CER,430PF,+-2%,50V,C0G,1206	851816	04222	12065A431GATBA	1	
C 5		CAP,TA,15UF,+-20%,6.3V	807636	56289	199D156X06R3BG2	1	
C 8, 9		CAP,POLYCA,0.027UF,+-10%,63V	720979	68919	MKC2273K63	2	
C 10		CAP,POLYES,0.47UF,+-10%,50V	697409	37942	185-2-474K50AA	1	
C 11		CAP,POLYPR,0.022UF,+-10%,63V	821579	68919	MKP20223K63V	1	
C 14, 21		CAP,TA,47UF,+-20%,10V,7343	867580	56289	293D476X0010D2T or W	2	
C 15, 16, 32		CAP,CER,0.1UF,+-10%,25V,X7R,1206	747287	04222	12065C104KATBA	3	
C 17, 18		CAP,CER,22PF,+-10%,50V,C0G,1206	740563	04222	12065A220KATBA	2	
C 20		CAP,CER,5.6PF,+-0.25PF,1500V,C0H	851811	91984	6010C0H5R6C1.5KVT14	1	
C 22		CAP,CER,1000PF,+-10%,50V,C0G,1206	747378	04222	12065A101KATBA	1	
C 24		CAP,TA,10UF,+-20%,10V	714766	56289	199D106X0010BE2	1	
C 27		CAP,CER,130PF,+-10%,50V,C0G,1206	911227	04222	12065A131KATBA	1	
C 28, 29		CAP,TA,0.47UF,+-20%,35V,3528	867259	56289	293D474X0035B2T or W	2	
C 30		CAP,CER,220PF,+-10%,50V,C0G,1206	758078	04222	12065A221KATBA	1	
C 26,31,33,34		CAP,CER,0.01UF,+-10%,50V,X7R,1206	747261	04222	12061C103KATBA	4	
C 35, 38		CAP,TA,4.7UF,+-20%,10V,3528	867262	56289	293D475X0010B2T or W	2	
C 36		CAP,CER,68PF,+-10%,50V,C0G,1206	853861	04222	12065A680KATBA	1	
C 39		CAP,CER,150PF,+/-5%,50V,C0G,0805	866533	04222	08055A151JATMA	1	
CR 1, 4		DIODE,SI,1K PIV,1.0 AMP	707075	04713	1N4007	2	
CR 5, 7, 8	*	DIODE,SI,BV=70.0V,IO=50MA,DUAL,SOT23	742320	25403	BAV99	3	
E 1		SURGE PROTECTOR,1500V,+-20%	655134	91984	100T1	1	
J 1		INPUT RCPT ASSY	826214	89536	826214	1	
J 2		SOCKET,1 ROW,PWB,0.100CTR,2 POS	832634	28213	929984-01-02	1	
Q 1, 2, 6	*	TRANSISTOR,SI,NPN,SELECT IEBO,SOT-23	821637	04713	SMBT1388L	3	
Q 3, 7, 9,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,SOT-23	742676	04713	MMBT3904L	4	
Q 12	*		742676				
Q 5, 11	*	TRANSISTOR,SI,PNP,SMALL SIGNAL,SOT-23	742684	04713	MMBT3906L	2	
Q 8	*	TRANSISTOR,SI,N-DMOS FET,SOT23	830851	17856	SSTVNS009	1	
Q 10	*	TRANSISTOR,SI,P-CHAN,SOT-23	832477	17856	SST175	1	
Q 13, 14	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,SOT-23	912469	04713	MMBT6429LT1	2	
R 1		RES,MF,1K,+-1%,100PPM,FLMPRF,FUSIBLE	832550	91637	CMF-65-69 1001F T-1,R36	1	1
R 2	*	RES,CERM,909K,+-1%,2W,100PPM	831594	23237	GS-3-909K-1%	1	
R 3	*	RES,CERM,1.5K,+-5%,.125W,200PPM,1206	746438	91637	CRCW1206-1501JB02	1	
R 4, 46		RES JUMPER,0.02,0.25W	682575	91637	FRJ-55	2	
R 5		RES,WW,.991,+-.1%,2.5W	821645	91637	RS-2C 9913F	1	
R 6		RES,WW,.010,+-.1%,1W,100PPM	807305	05347	Q426BR010B	1	
R 7, 10	*	RES,CERM,1M,+-5%,1W,200PPM	912589	89536	912589	2	
R 8	*	RES,CERM,0,+.05 MAX,.125W,1206	810747	91637	CRCW1206-0000FT	1	
R 9, 13, 29,	*	RES,CERM,100K,+-5%,.125W,200PPM,1206	740548	91637	CRCW1206-1003JB02	4	
R 53	*		740548				
R 11, 48	*	RES,CERM,10M,+-5%,.125W,300PPM,1206	783274	91637	CRCW1206-1005JB02	2	
R 12, 61- 66	*	RES,CERM,10K,+-5%,.125W,200PPM,1206	746610	91637	CRCW1206-1002JB02	7	
R 14		RES,MF,10K,+-0.1%,0.125W,100PPM	658955	59124	MF50D1002B	1	
R 15		RES,MF,90K,+-0.1%,0.125W,100PPM	658906	59124	MF50D9002B	1	
R 17, 18, 42,	*	RES,CERM,1M,+-5%,.125W,200PPM,1206	746826	91637	CRCW1206-1004JB02	4	
R 54	*		746826				
R 19	*	RES,CERM,107K,+-1%,.125W,100PPM,1206	875224	91637	CRCW1206-1073FB	1	
R 20	*	RES,CERM,412K,+-1%,.125W,100PPM,1206	875229	91637	CRCW1206-4123FB	1	
R 21		RES,VAR,CERM,100K,+-20%,.3W	649897	51406	RVG-0707-V-100-3-104M	1	
R 24	*	RES,CERM,324K,+-1%,.125W,100PPM,1206	911243	91637	CRCW1206-3243FB	1	
R 25	*	RES,CERM,210K,+-1%,.125W,100PPM,1206	821660	91637	CRCW1206-2103FB02	1	
R 30		RES,MF,20K,+-0.25%,0.125W,50PPM	715029	59124	MF50C2002C	1	
R 31, 40		RES,MF,22.6K,+-0.25%,0.125W,50PPM	715011	59124	MF50C2262C	2	
R 34		RES,VAR,CERM,1K,+-20%,.3W	831420	51406	RVG-0707-V-100-3-102M	1	
R 35	*	RES,CERM,665K,+-1%,.125W,100PPM,1206	867460	89536	867460	1	
R 37	*	RES,CERM,205K,+-1%,.125W,100PPM,1206	769836	91637	CRCW1206-2053FB02	1	
R 38	*	RES,CERM,536K,+-1%,.125W,100PPM,1206	845420	91637	CRCW1206-5363FB	1	
R 43		RES,MF,1K,+-0.1%,0.125W,100PPM	821694	59124	MF50D1001B	1	
R 44	*	RES,CERM,82K,+-5%,.125W,200PPM,1206	811794	91637	CRCW1206-8202JB02	1	
R 56, 57	*	RES,CERM,22K,+-5%,.125W,200PPM,1206	746651	91637	CRCW1206-2202JB02	2	
R 58	*	RES,CERM,120K,+-5%,.125W,200PPM,1206	746719	91637	CRCW1206-1203JB02	1	
R 59	*	RES,CERM,510,+-5%,.125W,200PPM,1206	746388	91637	CRCW1206-5100JB02	1	
R 67	*	RES,CERM,10K,+/-5%,.125W,200PPM,1206	746610	91637	CRCW1206-1002JB02	1	
RT 1		THERMISTOR,RECT,POS,1.5K,+-30%,25 C	822015	54583	911P84E152NU13	1	
RV 1, 2		VARISTOR,910,+-10%,1.0MA	876193	34371	V910LSX1399	2	
S 1		SWITCH,ROTARY	819334	89536	819334	1	
U 1		DIODE,SI,RECT,BRIDGE,BV=50V,IO=1A	418582	14936	DF01M	1	
U 4		SMX2 AUTOMOTIVE IC	921614	89536	921614	1	
U 6	*	IC,CMOS,HEX INVERTER,SOIC	838375	27014	MM5669UBM	1	
VR 1	*	IC,1.23V,60PPM TC,BAND-GAP REFERENCE	654707	27014	LM285BXZ-1.2D26Z	1	
XBT 1		CONNECTOR,BATTERY	825976	89536	825976	1	
XF 1		CONTACT,600V,FUSE	659524	89536	659524	1	
XF 2		600 VOLT FUSE CONTACT	707190	89536	707190	1	
Y 1		CRYSTAL,131.072KHZ,0.003%,3X8MM	831453	0ED74	IT6253G20	1	
Z 1		RES NET THN F TESTED	872213	89536	872213	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:1. THIS IS A FUSIBLE RESISTOR. TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.

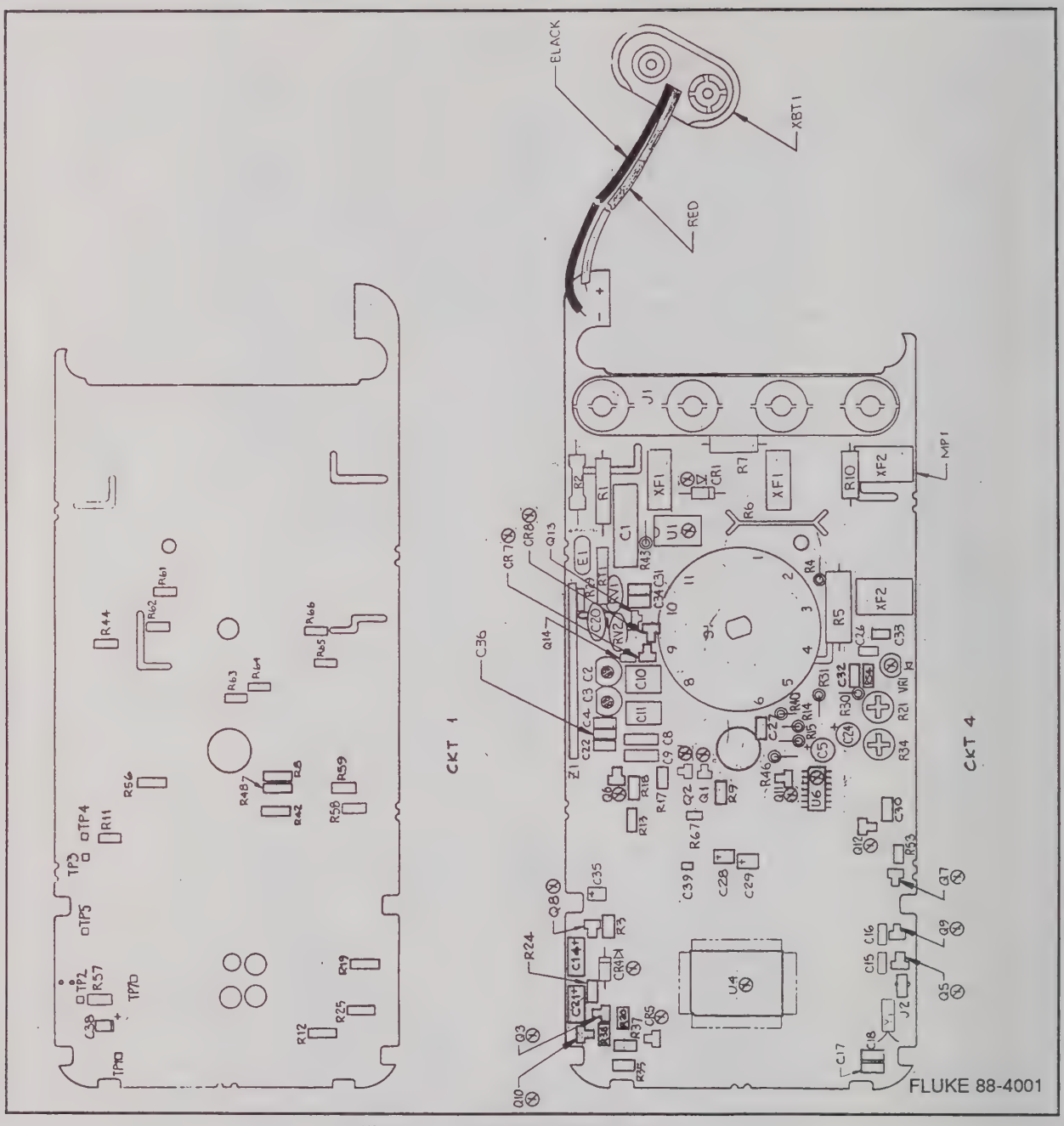


Figure 4-4. Fluke 88 A1 Main PCA

04222
AVX Kyocera Corp.
Myrtle Beach, SC

04713
Motorola Inc.
Semiconductor Products Sector
Phoenix, AZ

05347
Ultronix Inc
(Tel Labs)
Grand Junction, CO

0ED74
Daiwa Sangyo
Okinawa, Japan

0K392
Shin-Etsu Silicones of America
(S P America)
Torrance, CA

14936
General Instrument Corp.
Power Semiconductor Div.
Hicksville, NY

17856
Siliconix Inc.
Santa Clara, CA

22670
GM Nameplate, Inc.
Seattle, WA

23237
I R C, Inc.
Microcircuits Div
Philadelphia, PA

25403
Philips Components
Formerly Amperex Electronic Corp.
Slatersville, RI

27014
National Semiconductor Corp.
Santa Clara, CA

28213
Minnesota Mining & Mfg. Co.
Consumer Specialties Div.
3M Center
Saint Paul, MN

2K160
Parker Seal Co.
Div of Parker-Hannifin Corp.
Seattle, WA

34371
Harris Corp.
Semiconductor Sector
Military & Aerospace Div.
Melbourne, FL

37942
North American Capacitor Co.
Mallory Div.
Greencastle, IN

51406
Murata Erie, No. America Inc.
Symrna, GA

53718
Grace W R & Co.
Polyfibron Div/Airmold
Roanoke Rapids, NC

54583
TDK Electronics Corp.
Port Washington, NY

56289
Sprague Electric Co.
Nashua, NH

59124
KOA Speer Electronics Inc.
Bradford, PA

62786
Hitachi America Ltd.
Semiconductor & IC Div.
San Jose, CA

68919
Inter-Technical Group Inc.,
The Wima Division
Elmsford, NY

71400
Bussman - Now Magnum
Div. of Cooper Industries Inc.
St. Louis, MO

7X634
Saft America, Inc.
Advanced Battery Systems Div.
Valdese, NC

89536
John Fluke Mfg. Co., Inc.
Everett, WA

91637
Dale Electronics Inc.
Columbus, NE

91984
Maida Development Co.
Hampton, VA

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FAX: (714) 755-7332

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Fluke Service Center
W. 75 Century Rd
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FAX: 61-3-881-3636

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North Ryde, N.S.W. 2113
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Mohammed Fakhroo & Bros.
P.O. Box 439
Bahrain
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Bolivia
Casilla 7295,
Calle Ayacucho No. 208
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Philips Medical Systems, LTDA
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FAX: 42-2-364986

Data Elektronik BRNO
Jugoslavska 113
61300 Brno
TEL: 42-5-57400-2
FAX: 42-5-574002

Canada
Fluke Electronics Canada Inc.
400 Britannia Rd East, Ut #1
Mississauga, Ontario
L4Z 1X9
TEL: 905-890-7600
FAX: 905-890-6866

Chile
Intronica, Instrumen Electronica, S.A.C.I.
Guardia Vieja 181 Of. 503
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TEL: 56-2-232-6700

China
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TEL: 86-10-512-6351,6319, 3437
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Colombia
Sistemas E Instrument., Ltda.
Calle 83, No. 37-07
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Costa Rica
Electronic Engineering, S.A.
Carretera de Circunvalacion
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FAX: 506-225-1286

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41425 Sveta Jana
TEL: 385-41-837115
FAX: 385-41-837237

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Ejby Industrivej 40
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FAX: 45-43-43-9192

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TEL: 593-2-230283 or 520005
FAX: 593-2-561980

Egypt
EEMCO
Electronic Equipment Mkting Co.
9 Hassan Mazher St.
P.O. Box 2009
St. Heliopolis 11361
Cairo, Egypt
TEL: 20-2-417-8296
FAX: 20-2-417-8296

Fed. Rep. of Germany
Fluke Deutschland Gmbh
Customer Support Services
Servicestutzpunkt VFN5
Oskar-Messter-Strasse 18
85737 Ismaning/Munich
TEL: 49-89-9961-1260
FAX: 49-89-9961-1270

Fluke Deutschland
(CSS), Servicestutzpunkt VFN5
Meiendorfer Strasse 205
22145 Hamburg
TEL: 49-40-679-6434
FAX: 49-40-679-7653

Finland
Fluke Finland Oy
Sinikalliontie 3, P.L. 151
SF 02631 Espoo
TEL: 358-0-6152-5600
FAX: 358-0-6152-5630

France
Fluke France S.A.
37 Rue Voltaire
BP 112, 93700 Drancy, Cedex
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FAX: 33-1-4896-6330

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Fluke Sales & Service Manager
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Wanchai
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FAX: 852 834-1848

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P.O. Box 58
H 1502 Budapest
TEL: 361-186-9589 or 209-3444
FAX: 361-161-1021

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Taeknival HF
P.O. Box 8294, Skeifunni 17
128 Reykjavik
TEL: 354-1-681665
FAX: 354-1-680664

India
Hinditron Services Pvt. Inc.
33/44A 8th Main Road
Raj Mahal Vilas Extension
Bangalore 560 080
TEL: 91-80-334-8266 or 0068
FAX: 91-33-247-6844

Hinditron Services Pvt. Ltd
Hinditron House, 23-B
Mahal Industrial Estate
Mahakali Caves Rd, Andheri East
Bombay 400 093
TEL: 91-22-836-4560, 6590
FAX: 91-22-836-4682

Hinditron Services Pvt. Ltd
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5/1 A, Hungerford Street
Calcutta 700 017
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FAX: 91-33-247-6844

Hinditron Services Pvt. Ltd
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98 Nehru Place
New Delhi 110 019
TEL: 91-11-641-3675 or 643-0519
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FAX: 91-40-847585

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J/n H.R. Rasuna Said Kav. 3-4
Jakarta 12950
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FAX: 62-21-520-5189 or 62-21-520-5189

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Tel-Aviv 61580
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FAX: 972-3-647-8908

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20090 Vimodrone (Mi)
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FAX: 39-2-250-1645

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FAX: 254-2

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Seoul 135-010
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FAX: 82 12 546-1458

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Kangnam-Ku, Seoul
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Alghanim Industries
Airport Road Shuwaikh
13003 Kuwait
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FAX: 965-4847244

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Lebuhraya Batu Lancang
Taman Seri Damai
11600 Jelutong Penang
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FAX: 60-4-657-0835

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C.P. 03100, Mexico D.F.
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FAX: 52-5-687-8695

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Afdeling Service
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5692 EC Son
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FAX: 31-40-2678

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Private Bag 41904,
St. Lukes, 2 Wagener Place
Mt. Albert, Auckland 3
TEL: 64-9-894-4160
FAX: 64-9-849-7814

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Philips Projects Centre
Resident Delegate / PMB 80065
8, Kofo Abayomi Street
Victoria Island, Nigeria
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FAX: 234-1-262-0631

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Fluke Norway A/S, Cust. Support
P.O. Box 6054 Etterstad
N-0601 Oslo
TEL: 47-22-653400
FAX: 47-22-653407

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Philips Elec. Ind. of Prof. Sys. Div.
Islamic Cham. of Commerce
St-2/A, Block 9, KDA Scheme 5,
Clifton, Karachi-75600
TEL: 92-21-587-4641 or 4649
FAX: 92-21-577-0348

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Impor. & Repres. Electronicas
S.A., JR. Pumacahua 955
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TEL: 51-14-23-5099
FAX: 51-14-31-0707

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Metro Manila 1502
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FAX: 63-2-721-0491 or 700-709

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Elec. Instr. Srv. Philips Cons.
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60 188 Poznan
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FAX: 48-61-682256

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Sasles Y Services Dept
Campo Grande 35 - 7b
1700 Llsboa
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FAX: 351-1-795-1713

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Ronex S.R.L., Cust. Supp. Serv.
Str. Transilvaniei Nr. 24
70778 Bucharest - I
TEL: 40-1-614-3597 or 3598
FAX: 40-1-659-4468

Russia
Infomedia
UL. Petrovsko Razumovsky
Proezd. 29
103287 Moscow
TEL: 7-95-212-3833
FAX: 7-95-212-3838

Saudi Arabia
A. Rajab & Silsilah Co. S&S Dept.
P.O. Box 203
21411 Jeddah
TEL: 966-2-661-0006
FAX: 966-2-661-0558

Singapore
Fluke Singapore Pte., Ltd.
Fluke ASEAN Regional Office
#27-03 PSA Building
460 Alexandra Road
Singapore 119963
TEL: 65-276-5161
FAX: 65-*-276-5929

South Africa
Spescom Measure. (PTY) Ltd.
Spescom Park
Crn. Alexandra Rd. & Second St.
Halfway House, Midrand 1685
TEL: 27-11-315-0757
FAX: 27-11-805-1192

Spain
Fluke Iberica S.L.
Centro Empresarial Euronora
c/Ronda de Poniente, 8
28760-Tres Cantos
Madrid, Spain
TEL: 34-1-804-2301
FAX: 34-1-804-2496

Sweden
Fluke Sverige AB, (CSS)
P.O. Box 61
S-164 94 Kista
TEL: 46-8-751-0235 or 0230
FAX: 46-8-751-0480

Switzerland
Fluke Switzerland AG, (CSS)
Rutistrasse 28
CH 8952 Schlieren
Switzerland
TEL: 41-1-730-3310 or 730-3932
FAX: 41-1-730-3932

Taiwan
Schmidt Scientific Taiwan, Ltd.
6th Floor, No. 109,
Tung Hsing Street
Taipei, Taiwan R.O.C.
TEL: 886-2-767-8890 or 746-2720
FAX: 886-2-767-8820

Thailand
Measuretronix Ltd.
2102/31 Ramkamhang Road
Bangkok 10240
TEL: 66-2-375-2733 or 2734
FAX: 66-2-374-9965

Turkey
Pestas Prof. Elektr. Sist. Tic. V
Selcuklar Caddesi
Meydan Apt. No. 49, Daire 23
Akatlar 80630 Istanbul
TEL: 90-212-282-7838
FAX: 90-212-282-7839

U.A.E.
Haris Al Afaq Ltd.
P.O. Box 8141
Dubai
TEL: 971-4-283623 or 283624
FAX: 971-4-281285

United Kingdom
Fluke U.K. LTD. (CSS)
Colonial Way
Watford, Hertfordshire WD2 4TT
TEL: 44-923-240511
FAX: 44-923-225067

Uruguay
Coasin Instromontos S.A.
Casilla de Correo 1400
Libertad 2529, Montevideo
TEL: 598-2-492-436, 659
FAX: 598-2-492-659

Venezuela
Coasin C.A.
Calle 9 Con Calle 4, Edif. Edinurbi
Piso-3
La Urbina
Caracas 1070-A, Venezuela
TEL: 58-2-241-6214
FAX: 58-2-241-1939

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Schmidt-Vietnam Co., Ltd.
8/Fl. Schmidt Tower
Hanoi International Tech. Ctr
KM8, Highway 32, Cau Giay
Tu Liem, Hanoi
Vietnam
TEL: 84-4-346186 or 346187
FAX: 84-4-346-188

West Indies
Western Scientific Co., Ltd.
Freeprot Mission Road
Freeport, Trinidad
West Indies
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FAX: 809-673-0767

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Jugoelektro Beograd
T & M Customer Support
Servicies
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11070 Novi
TEL: 38-11-182470
FAX: 38-11-638209

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Field Technical Sales
45, Kelvin Road North
P.O. Box Cy535 Causeway
Harare, Zimbabwe
TEL: 263-4-750381 or 750382
FAX: 263-4-729970

Section 5
Schematics and Signal Flow Diagrams

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Table 5-1. Signal Abbreviations

ABBREVIATIONS	SIGNAL
ACBM	AC Buffer Minus (inverting input)
ACBO	AC Buffer Output
AFI	Active Filter Input
AFO	Active Filter Output
AGND	Analog Ground
AP0	Analog Port 0 (guard)
AP1	Analog Port 1 (ohms, millivolts sense)
AP2	Analog Port 2 (ohms reference sense)
AP3	Analog Port 3 (amps sense)
AP4	Analog Port 4 (milli/micro amps jack sense)
AP5	Analog Port 5 (amps jack sense)
AP6	Analog Port 6 (PTF position sense)
AP7	Analog Port 7 (peak hold min sense)
AP8	Analog Port 8 (peak hold max sense)
APV0	Analog Port Voltage 0 (divider input)
APV1	Analog Port Voltage 1 (divide by 10)
APV2	Analog Port Voltage 2 (divide by 100)
APV3	Analog Port Voltage 3 (divide by 1000)
APV4	Analog Port Voltage 4 (divide by 10000)
APCC	Analog Port Compensation Capacitor
AVAM	Absolute Value Amplifier Minus (inverting input)
AVAOM	Absolute Value Amplifier Output Minus
AVAOP	Absolute Value Amplifier Output Positive
AZ	Auto Zero
CK1	Clock 1 (RC clock output)
CK2	Clock 2 (RC clock input)
COM	Common
FAI	Filter Active Input
FAO	Filter Active Output
H1	LCD backplane drive 1
.	.
.	.
H4	LCD backplane drive 4
INT	Integrator output
KO	Buffer output times .874
K1	Buffer output times 1
K2	Buffer output times 10
PDS	Power Down (off) Signal
P00	Port 00 (keypad)
P01	Port 01 (keypad)
P02	Port 02 (keypad)
P03	Port 03 (PTF reference and position change sense)
P10	Port 10 (keypad)
P11	Port 11 (keypad)
P12	Port 12 (keypad)
P13	Port 13 (PW2, RMS power down drive)
PSO	Power Supply 0 (feedback for VDD regulator)
PS1	Power Supply 1 (feedback for common regulator)
PS2	Power Supply 2 (output for common regulator)
REFH	Reference High (1.23V)
REFI	Reference In (1.00V)

Table 5-1. Signal Abbreviations (cont)

ABBREVIATIONS	SIGNAL
RESET	Reset for μP
S0	LCD Segment drive 0
•	•
•	•
S31	LCD Segment drive 31
TEST	Factory test
VBT+	Plus battery voltage
VBT-	Minus battery voltage
VDD	Plus system supply
VDGND	Digital Ground
VOA	2/3 voltage for LCD drive
VOB	1/3 voltage for LCD drive
VSS	Minus system supply

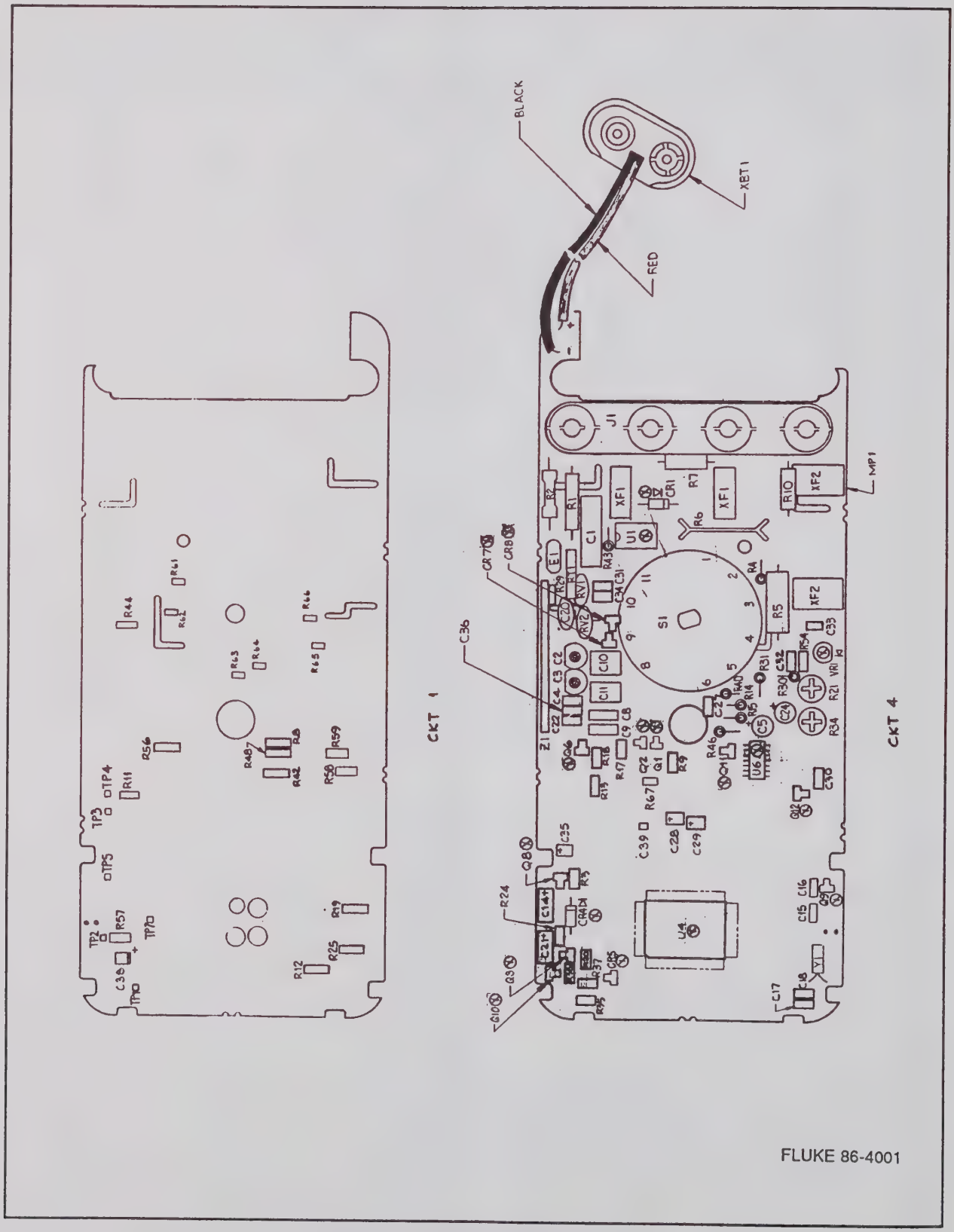
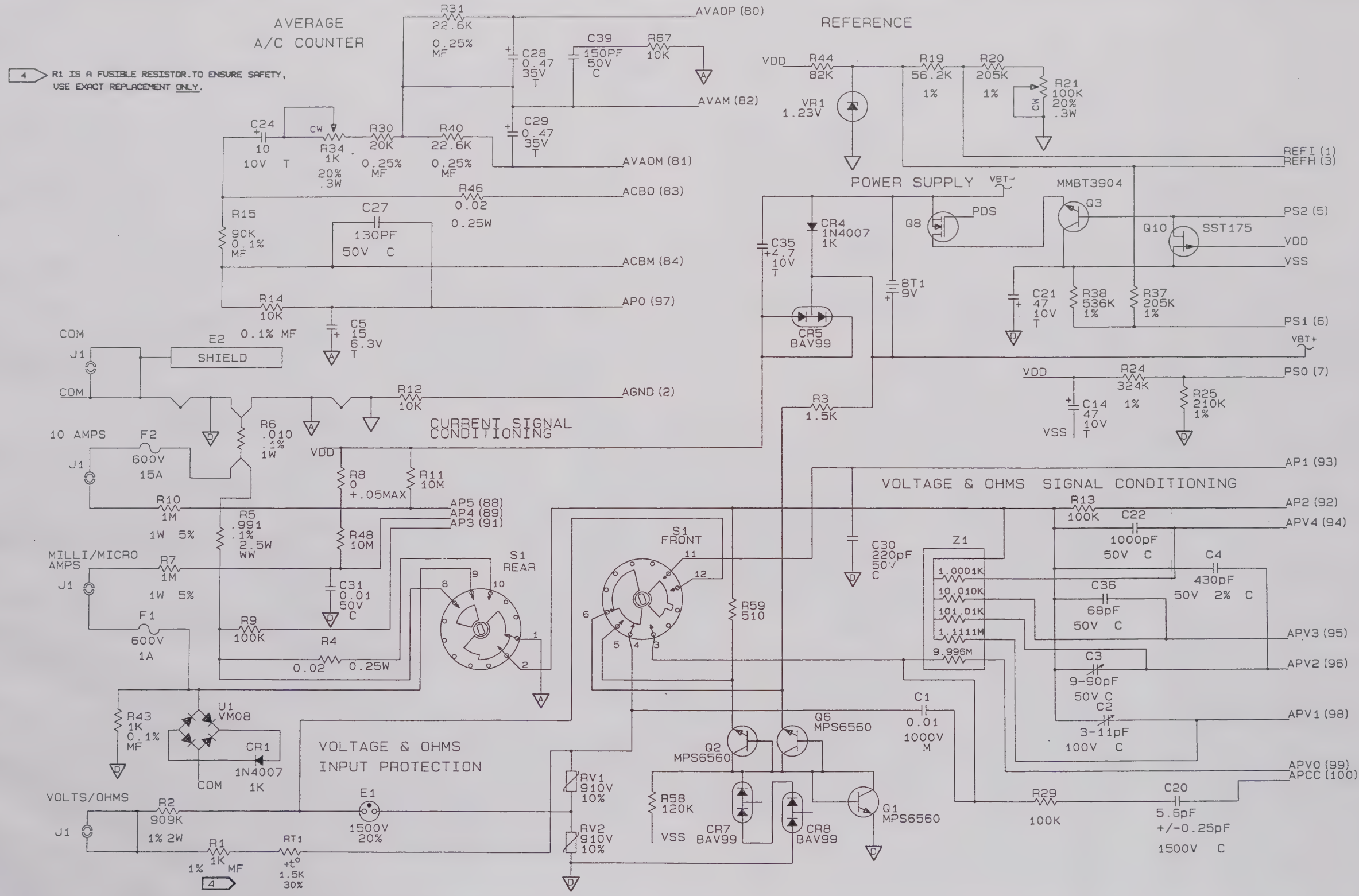
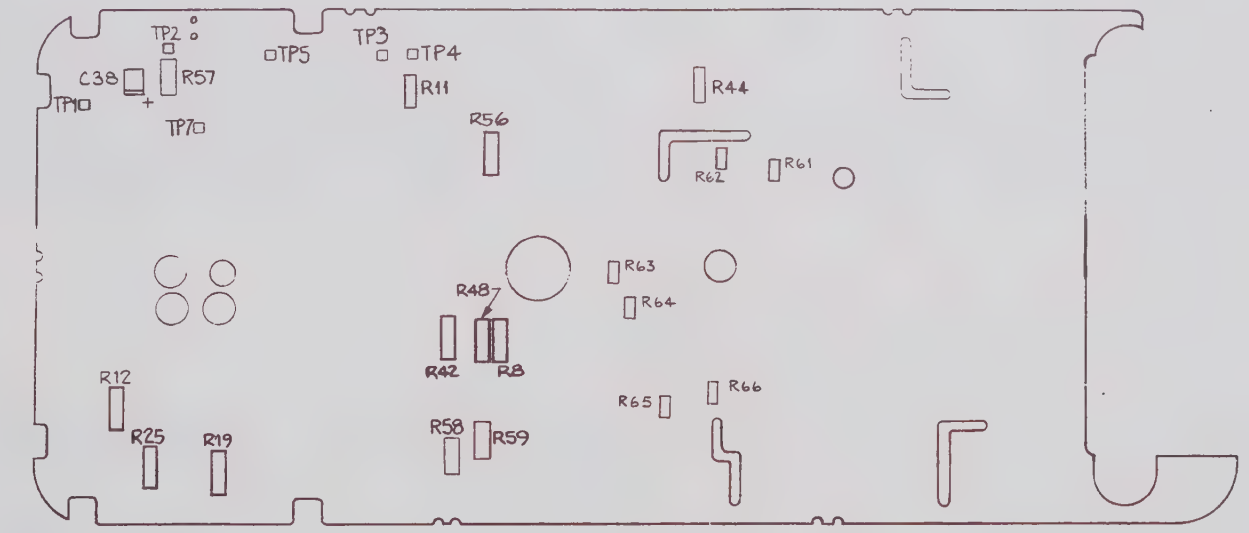


Figure 5-1. Fluke 86 A1 Main PCA

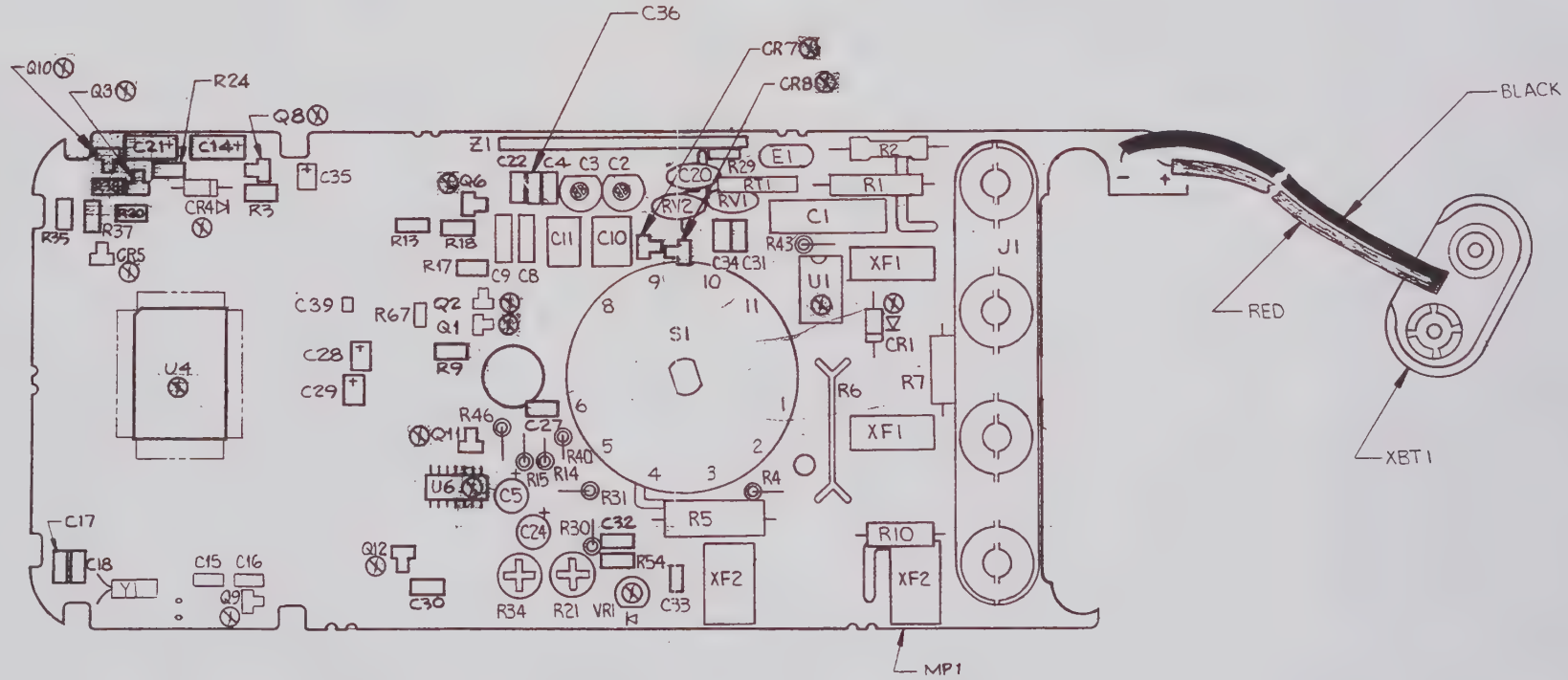


FLUKE 86-1221
(1 of 2)

Figure 5-1. Fluke 86 A1 Main PCA (cont)



CKT 1



CKT 4

FLUKE 86-4001

Figure 5-1. Fluke 86 A1 Main PCA (cont)

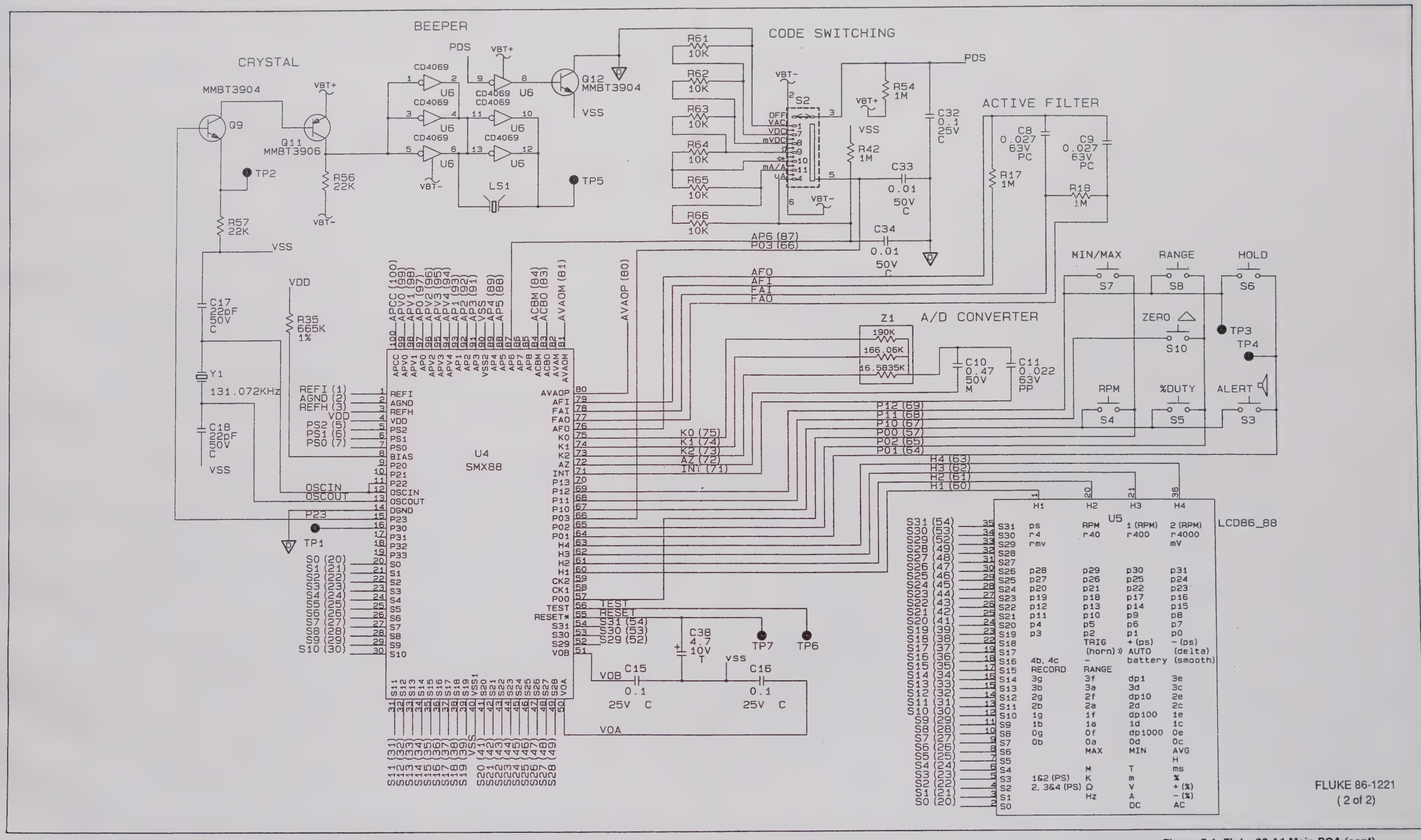
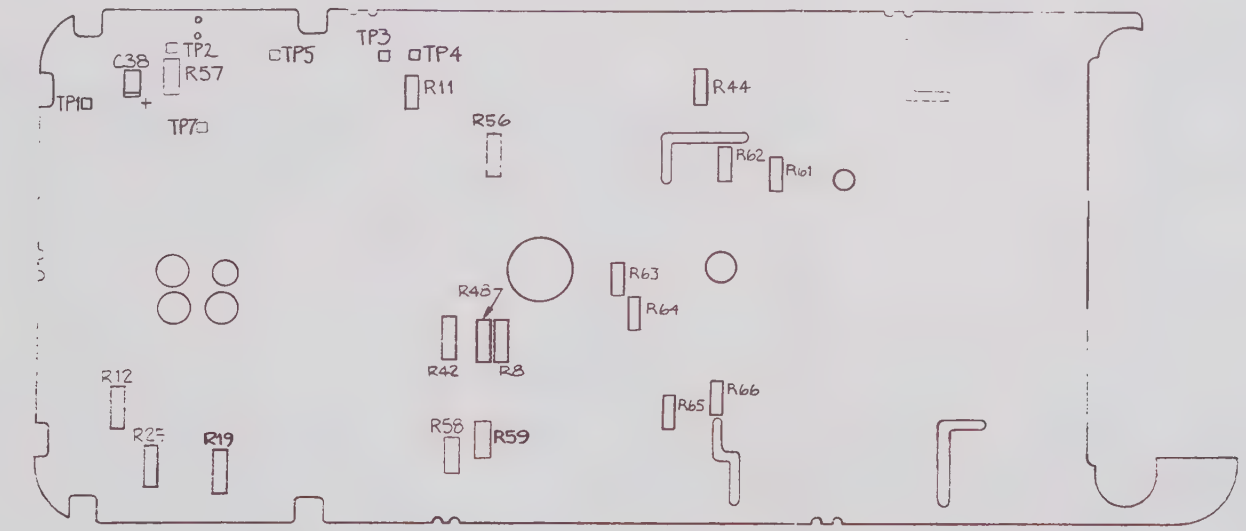
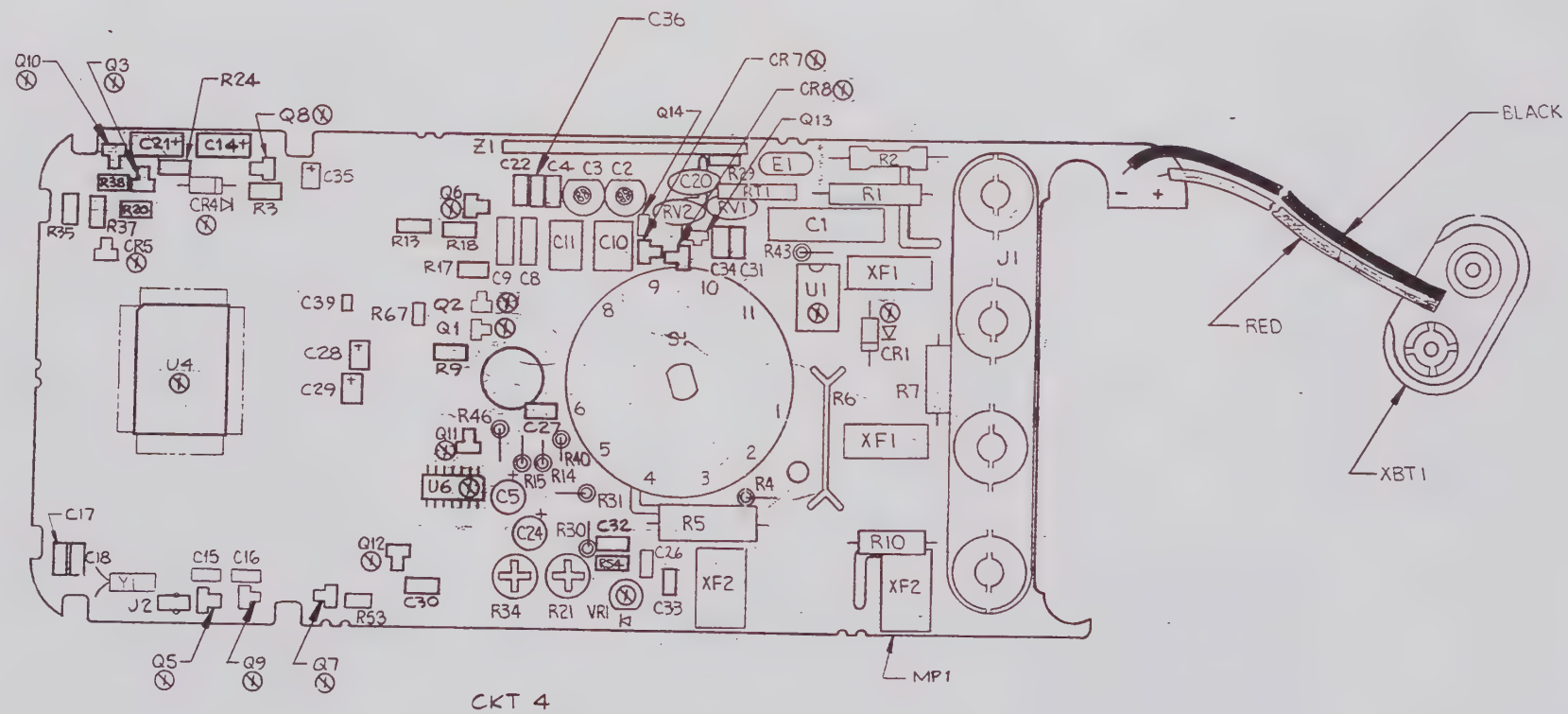


Figure 5-1. Fluke 86 A1 Main PCA (cont)



CKT 1



CKT 4

Figure 5-2. Fluke 88 A1 Main PCA

4 R1 IS A FUSIBLE RESISTOR.TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.

AVERAGE A/C COUNTER

REFERENCE

POWER SUPPLY

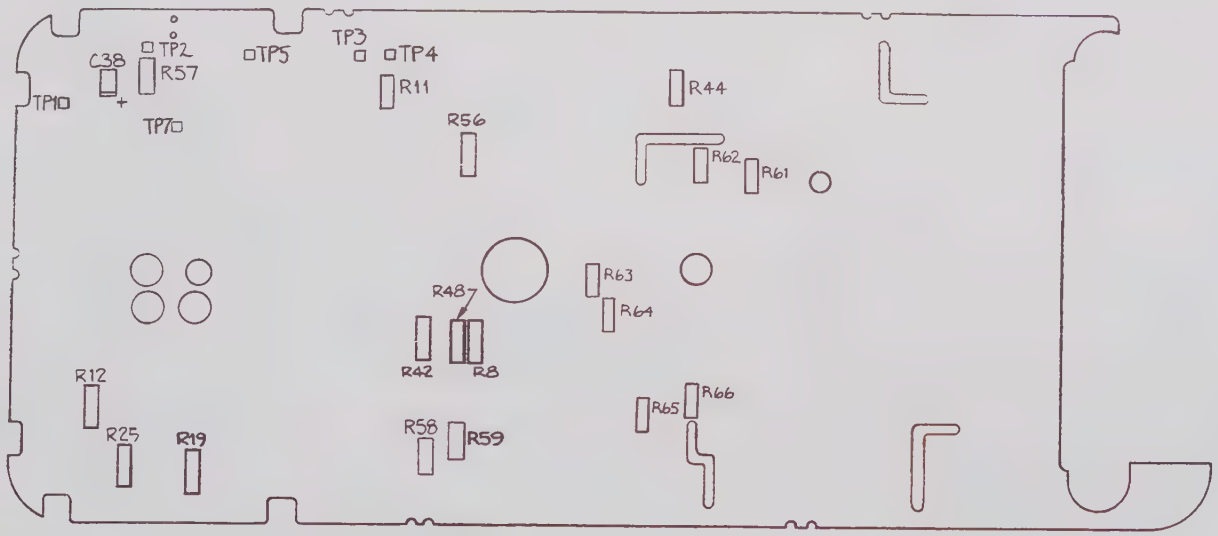
CURRENT SIGNAL CONDITIONING

VOLTAGE & OHMS SIGNAL CONDITIONING

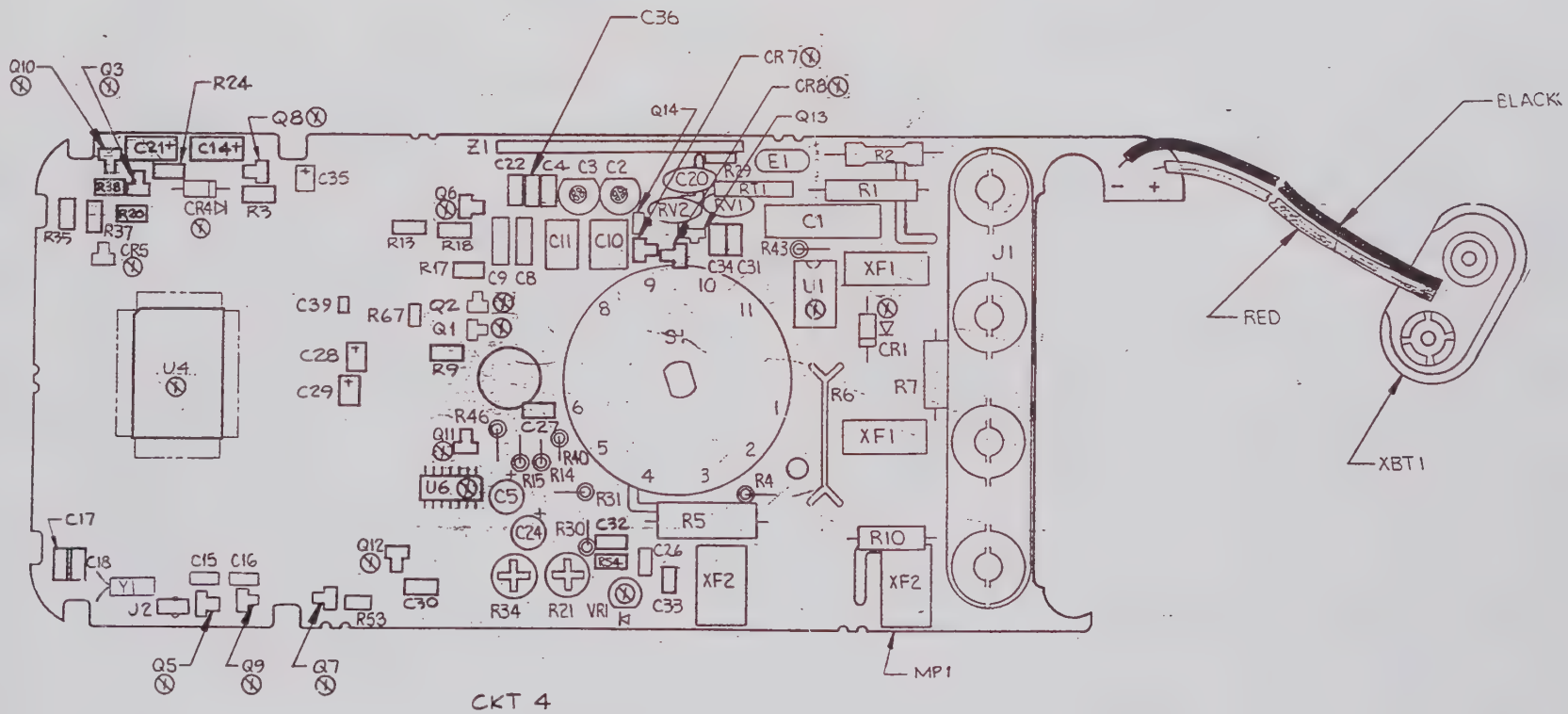
VOLTAGE & OHMS INPUT PROTECTION

FLUKE 88-1221
(1 of 2)

Figure 5-2. Fluke 88 A1 Main PCA (cont)

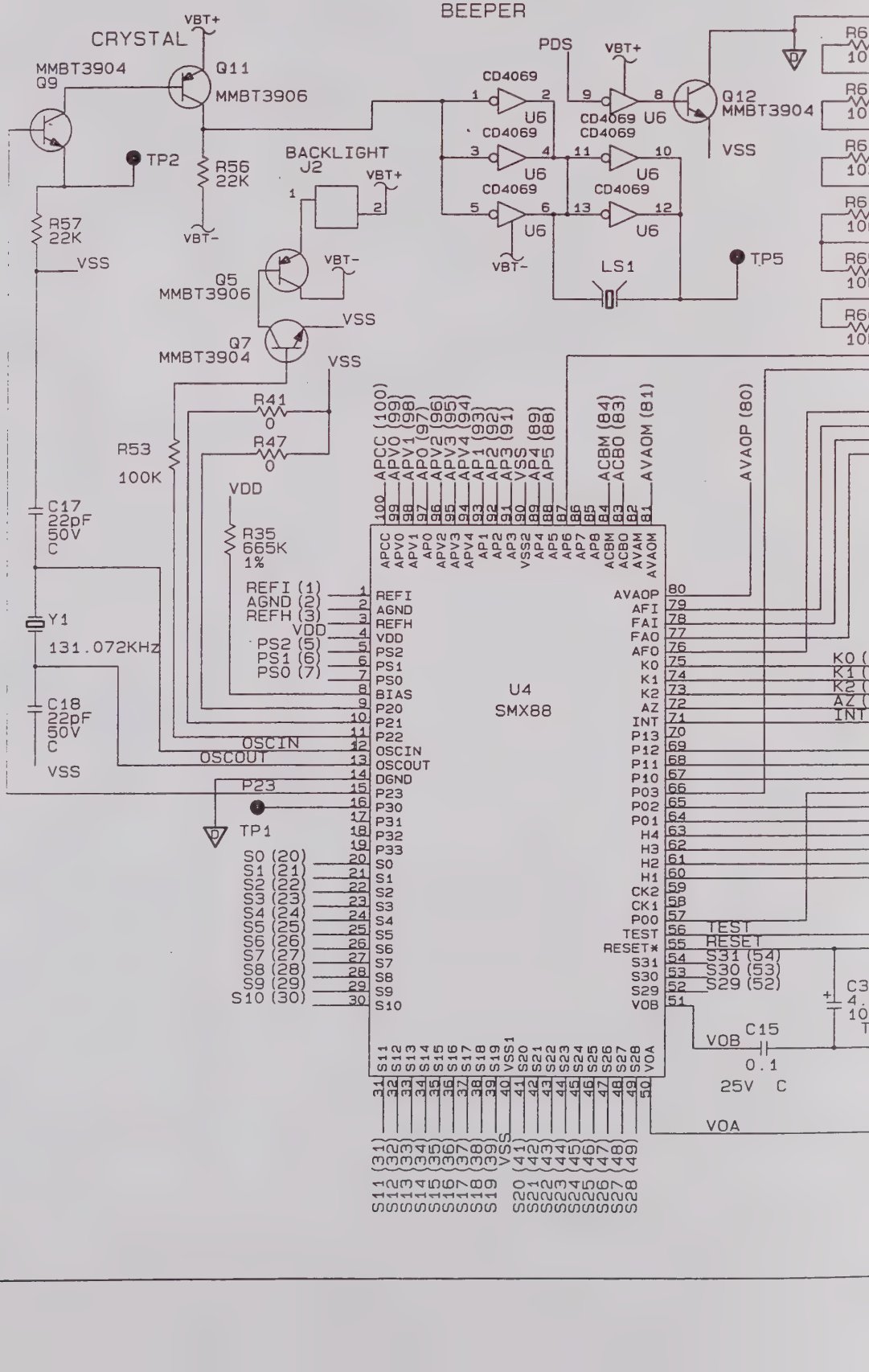


CKT 1



CKT 4

Figure 5-2. Fluke 88 A1 Main PCA (cont)


BEEPER
CRYSTAL
VBT+
MMBT3904
Q9
Q11
MMBT3906
TP2
R56
22K
R57
22K
VSS
VBT-
BACKLIGHT
J2
Q5
MMBT3906
Q7
MMBT3904
PDS
CD4069
U6
Q12
MMBT3904
LS1
TP5
R41
0
R47
0
R53
100K
VDD
R35
665K
1%
C17
22pF
50V
C
Y1
131.072KHz
C18
22pF
50V
C
OSCIN
OSCOUT
P23
TP1
U4
SMX88
REFI (1)
AGND (2)
REFH (3)
PS2 (5)
PS1 (6)
PS0 (7)
S0 (20)
S1 (21)
S2 (22)
S3 (23)
S4 (24)
S5 (25)
S6 (26)
S7 (27)
S8 (28)
S9 (29)
S10 (30)
AVAOP (80)
AVAOM (81)
ACBO (83)
ACBM (84)
TEST
RESET*
S31 (54)
S30 (53)
S29 (52)
C15
0.1
25V C
VOB
VOA

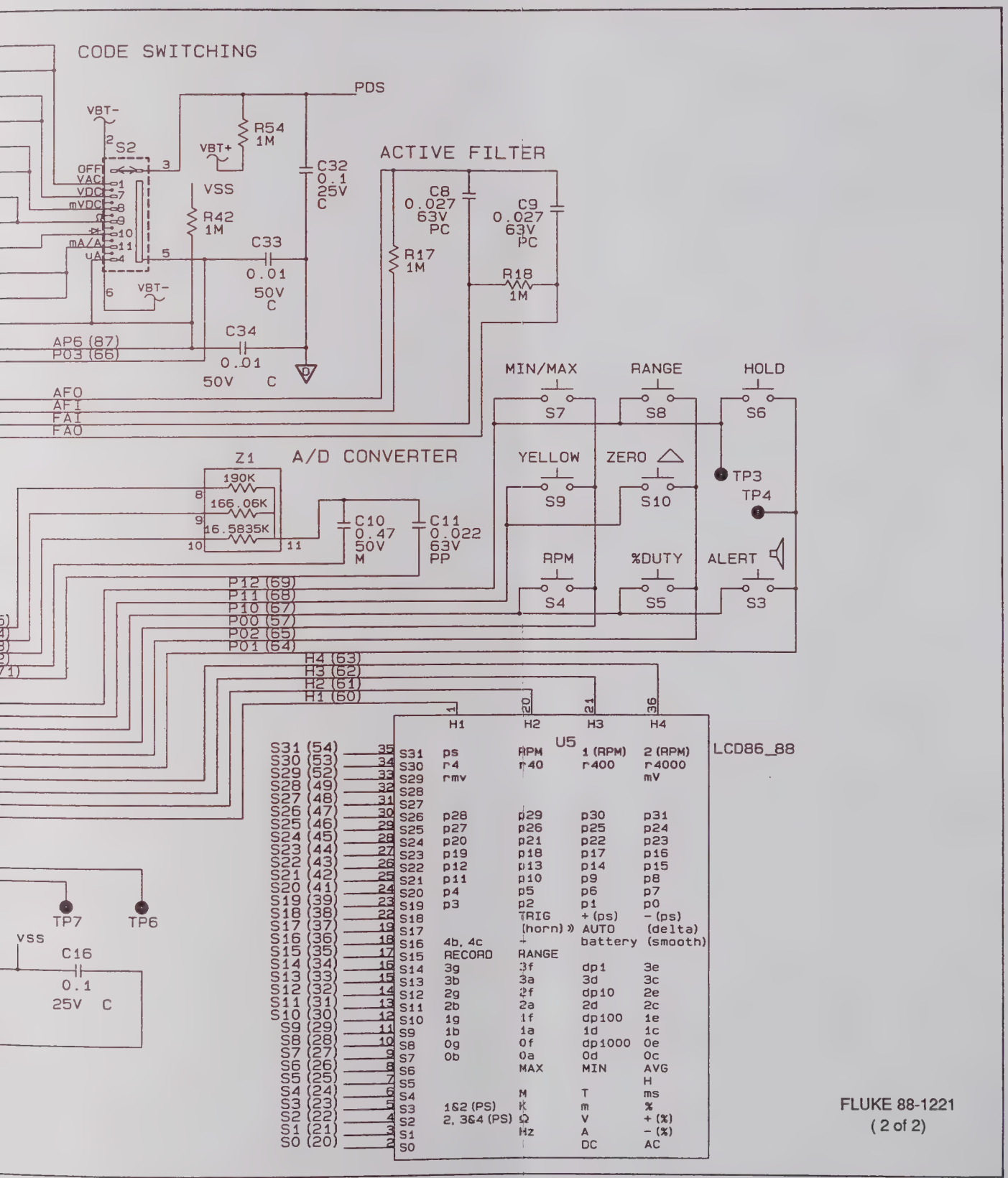
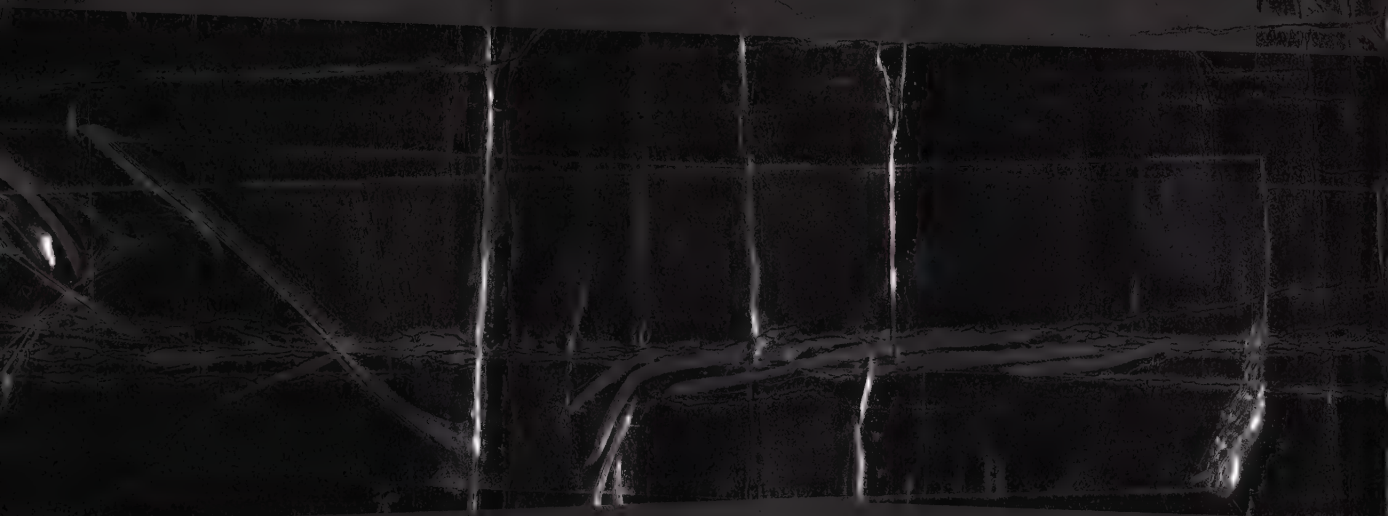


Figure 5-2. Fluke 88 A1 Main PCA (cont)



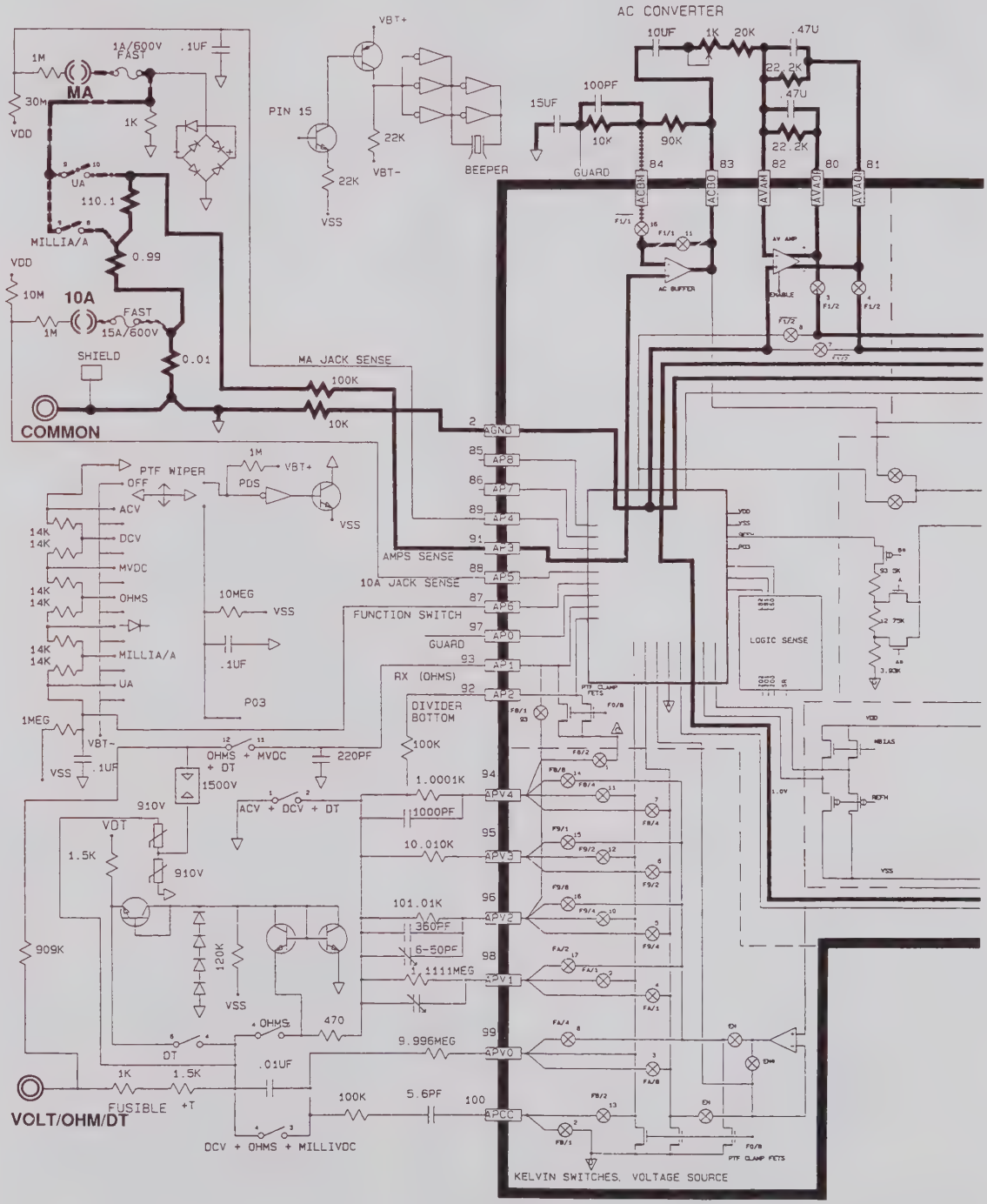
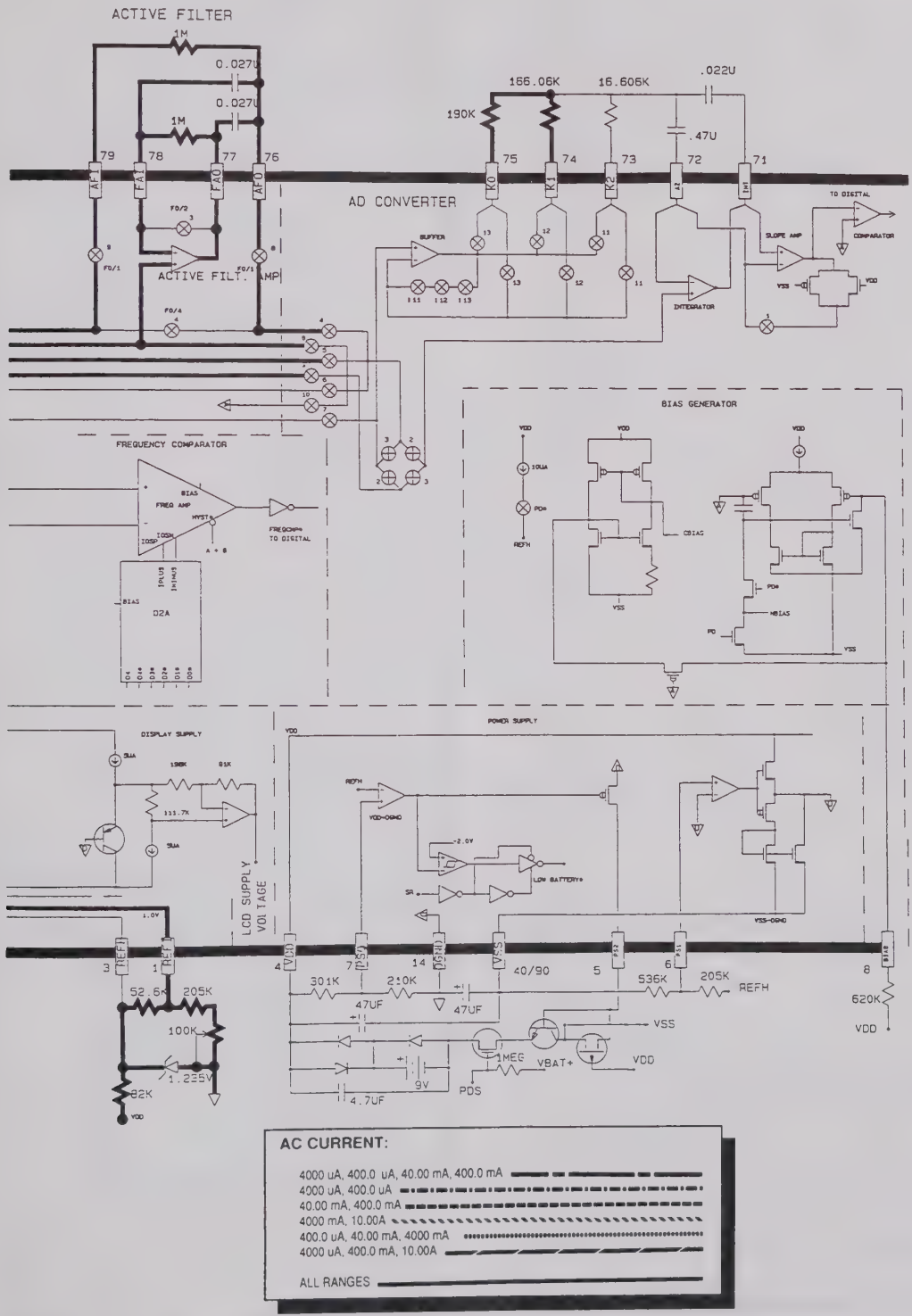


Figure 5-3. AC Current Signal Flow


ACTIVE FILTER
1M
0.027U
0.027U
1M
79
78
77
76
AF1
FA1
FA0
AF0
FO/2
FO/1
FO/1
FO/4
ACTIVE FILT. AMP
AD CONVERTER
166.06K
16.606K
.022U
190K
.47U
75
74
73
72
71
K0
K1
K2
A2
1M
BUFFER
I11
I12
I13
INTEGRATOR
SLOPE AMP
COMPARATOR
TO DIGITAL
VDD
VSS
FREQUENCY COMPARATOR
BIAS
FREQ AMP
HYSTA
COSH
ZOSP
A + B
FREQCMP+
TO DIGITAL
D2A
BIAS GENERATOR
VDD
10UA
PD=
REFH
CBIAS
VSS
PD=
HBIAS
PD
VSS
DISPLAY SUPPLY
5UA
190K
91K
111.7K
5UA
1.0V
LCD SUPPLY VOLTAGE
POWER SUPPLY
VDD
REFH
VDD-DGND
-2.0V
LOW BATTERY=
SR
VSS-DGND
3
1
4
7
14
6
5
8
REF-
REF+
VDD
PDS
DGND
VSS
40/90
R32
R31
R16
301K
210K
536K
205K
REFH
620K
VDD
47UF
47UF
VSS
52.6K
205K
100K
1.225V
82K
VDD
1MEG
VBAT+
VDD
9V
PDS
4.7UF
AC CURRENT:
4000 uA, 400.0 uA, 40.00 mA, 400.0 mA
4000 uA, 400.0 uA
40.00 mA, 400.0 mA
4000 mA, 10.00A
400.0 uA, 40.00 mA, 4000 mA
4000 uA, 400.0 mA, 10.00A
ALL RANGES

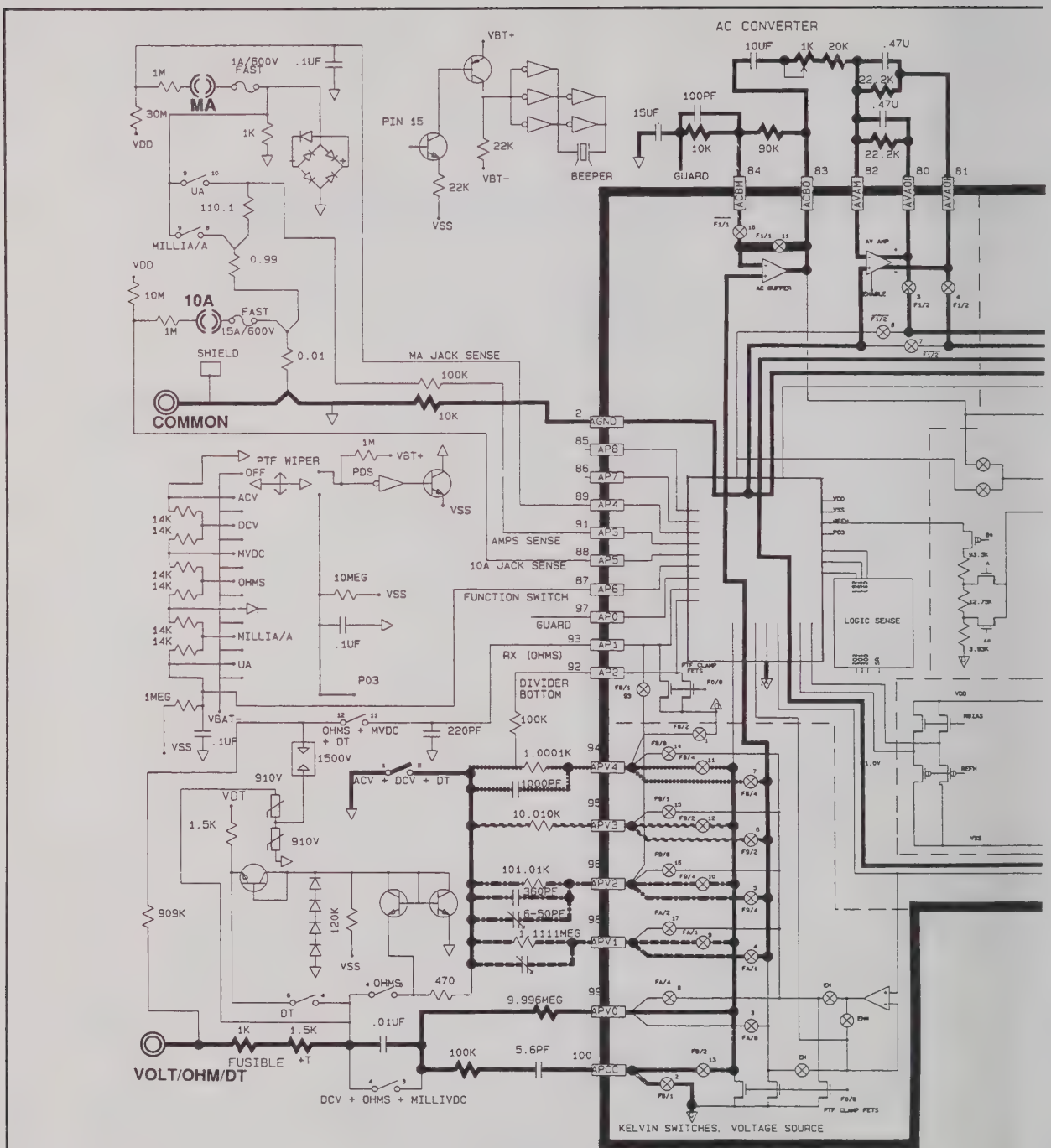
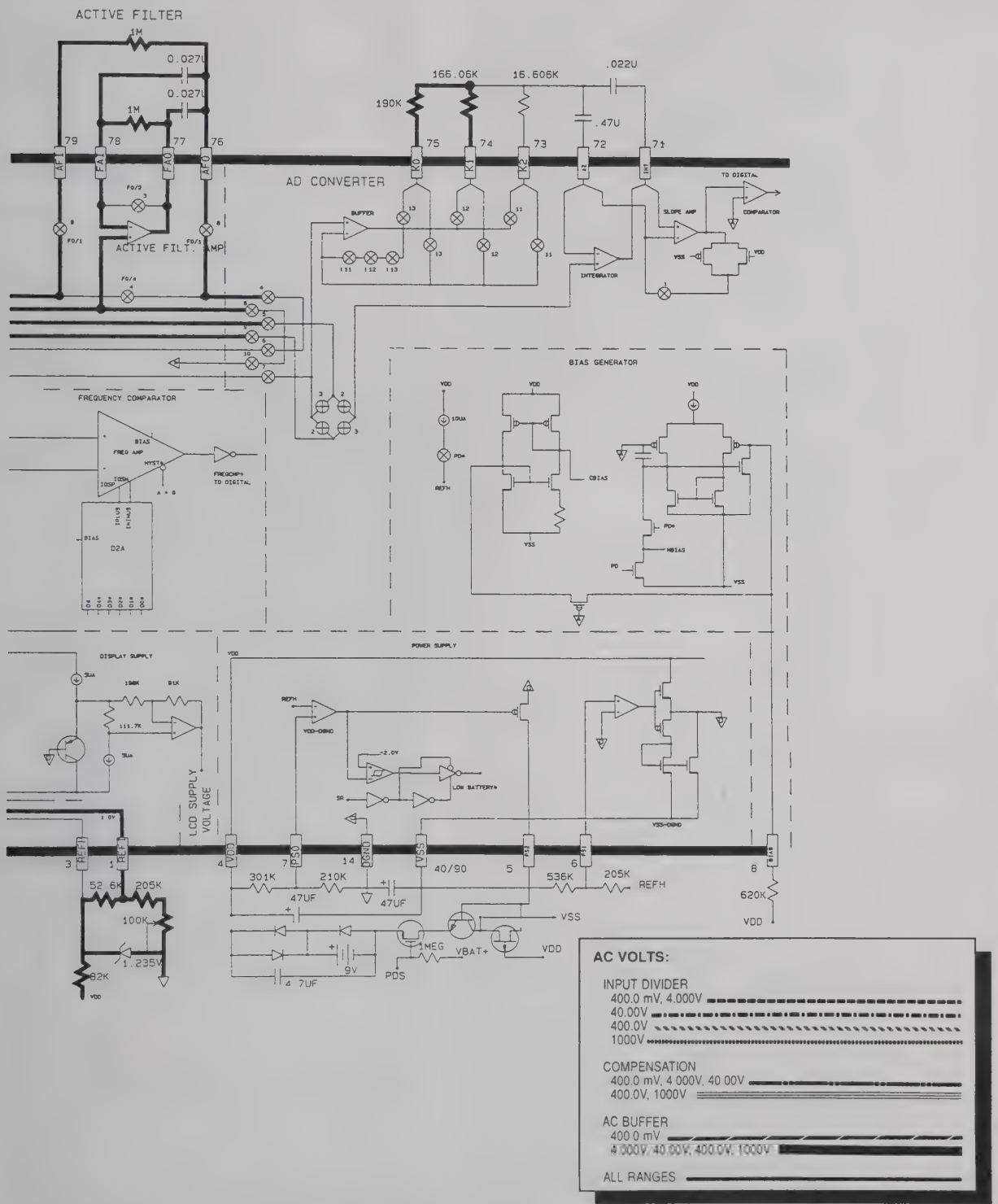


Figure 5-4. AC Volts Signal Flow


ACTIVE FILTER
1M
0.027U
0.027U
1M
79
78
77
76
AF1
FA1
FA0
AF0
AD CONVERTER
165.06K
15.606K
.022U
190K
.47U
75
74
73
72
71
K0
K1
K2
INT
BUFFER
ACTIVE FILT. AMP
FREQUENCY COMPARATOR
BIAS GENERATOR
POWER SUPPLY
DISPLAY SUPPLY
LCD SUPPLY VOLTAGE
AC VOLTS:
INPUT DIVIDER
400.0 mV, 4.000V
40.00V
400.0V
1000V
COMPENSATION
400.0 mV, 4.000V, 40.00V
400.0V, 1000V
AC BUFFER
400.0 mV
4.000V, 40.00V, 400.0V, 1000V
ALL RANGES

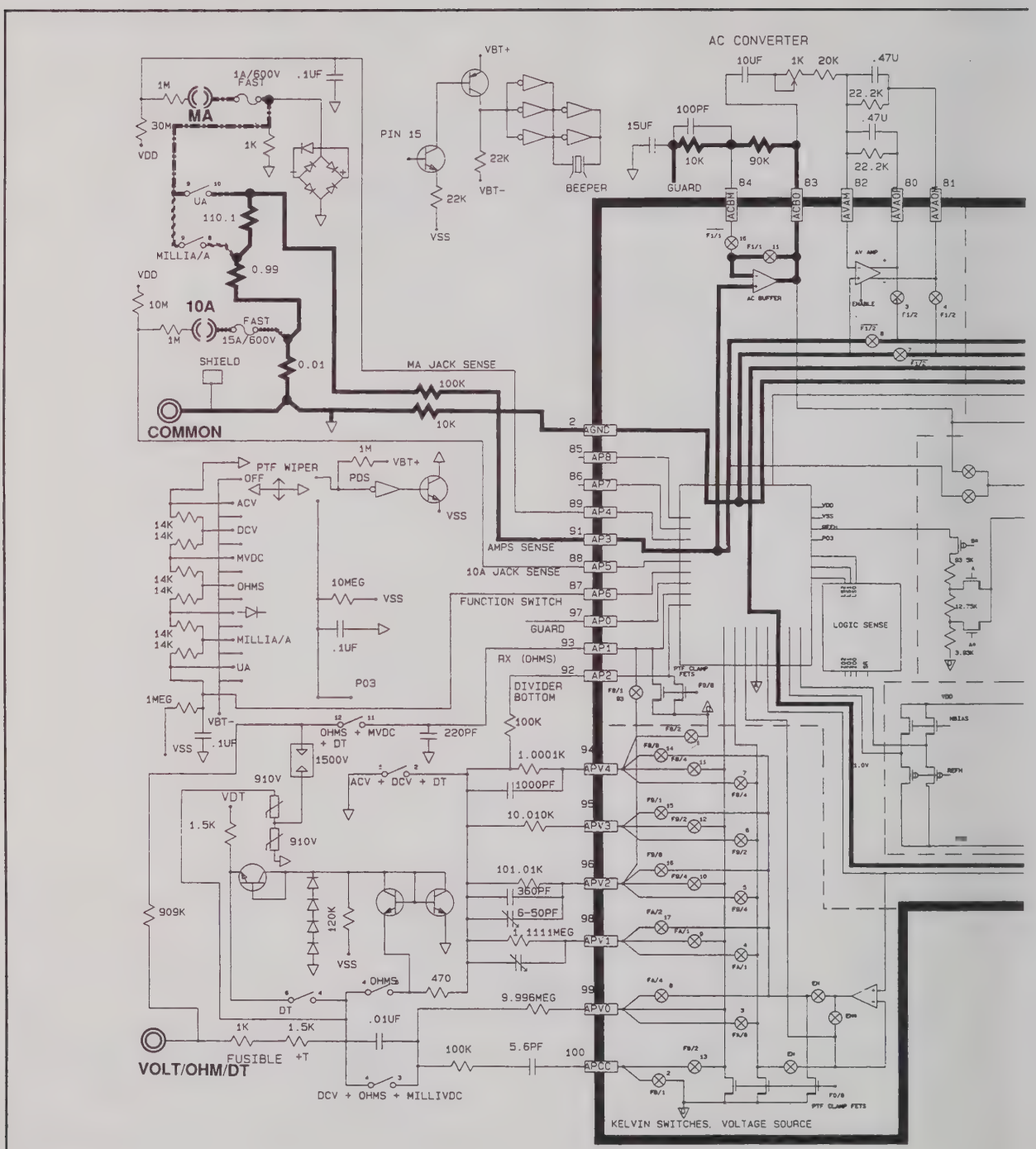
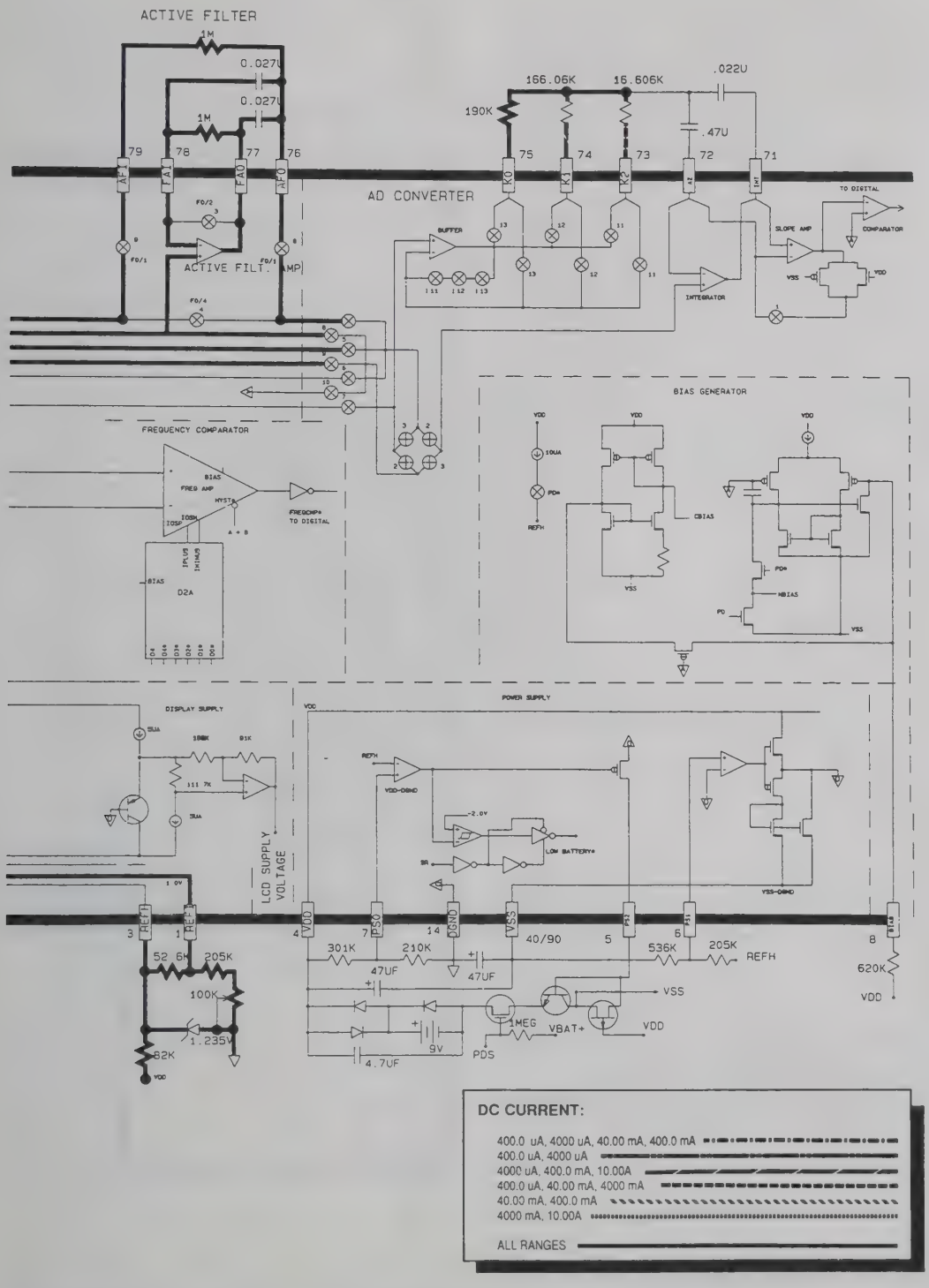


Figure 5-5. DC Current Signal Flow


ACTIVE FILTER
AD CONVERTER
BIAS GENERATOR
FREQUENCY COMPARATOR
DISPLAY SUPPLY
POWER SUPPLY
LCD SUPPLY VOLTAGE
TO DIGITAL
SLOPE AMP
COMPARATOR
INTEGRATOR
BUFFER
ACTIVE FILT. AMP
D2A
VDD
VSS
REFH
REFL
PDS
VBAT+
LOW BATTERY
DC CURRENT:
400.0 uA, 4000 uA, 40.00 mA, 400.0 mA
400.0 uA, 4000 uA
4000 uA, 400.0 mA, 10.00A
400.0 uA, 40.00 mA, 4000 mA
40.00 mA, 400.0 mA
4000 mA, 10.00A
ALL RANGES

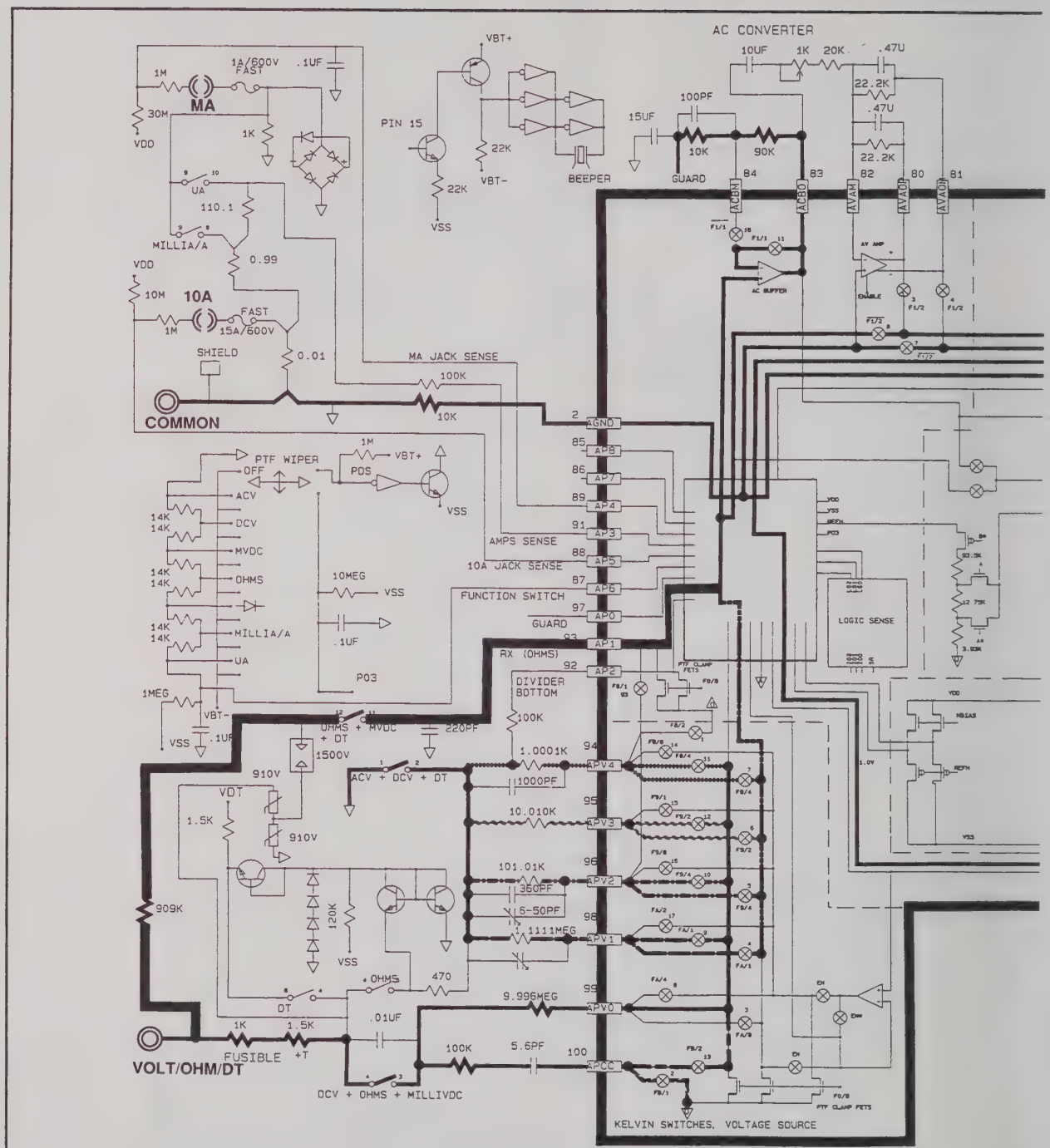
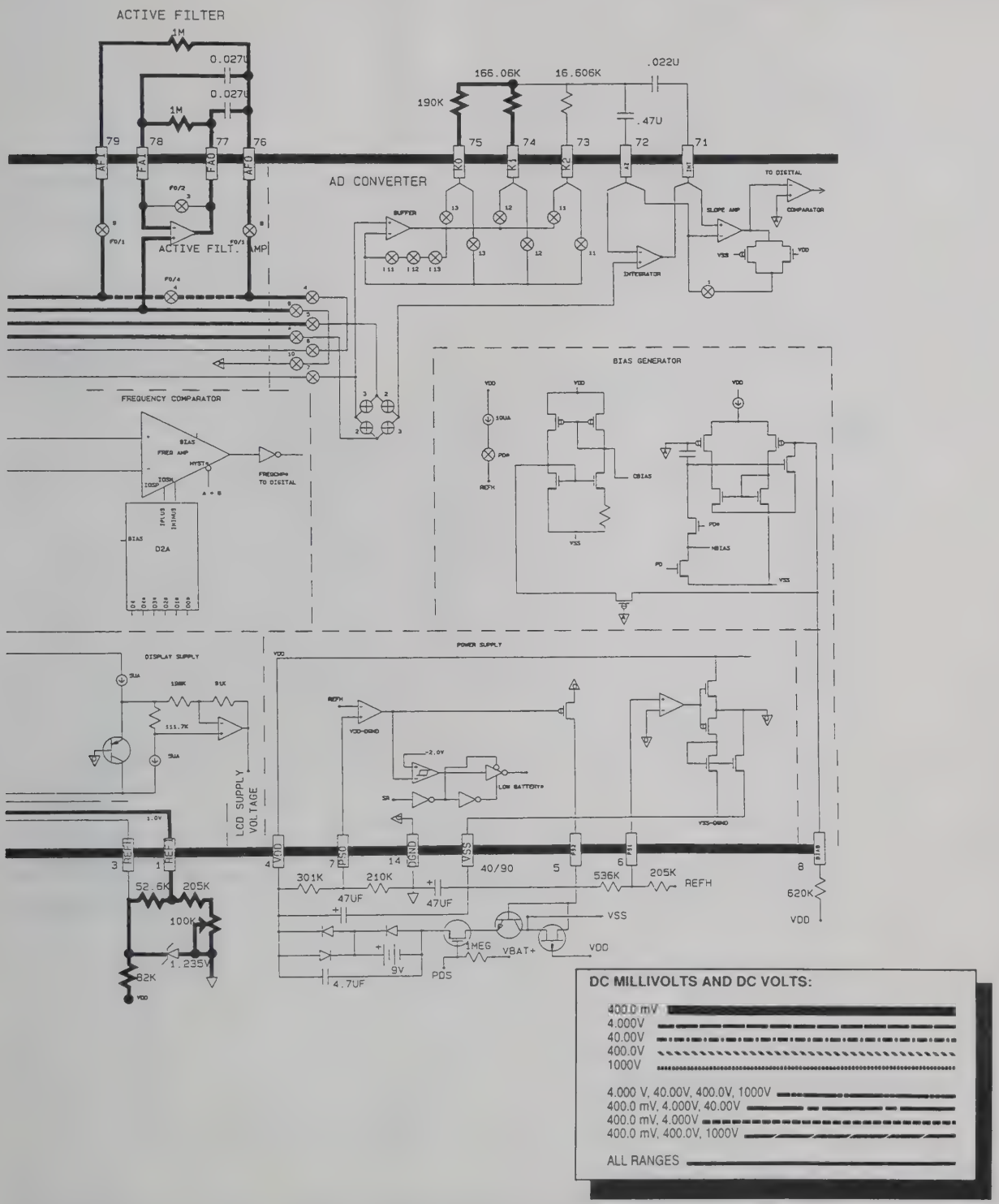


Figure 5-6. DC Millivolts and DC Volts Signal Flow



DC MILLIVOLTS AND DC VOLTS:

400.0 mV
4.000V
40.00V
400.0V
1000V

4.000 V, 40.00V, 400.0V, 1000V
400.0 mV, 4.000V, 40.00V
400.0 mV, 4.000V
400.0 mV, 400.0V, 1000V

ALL RANGES

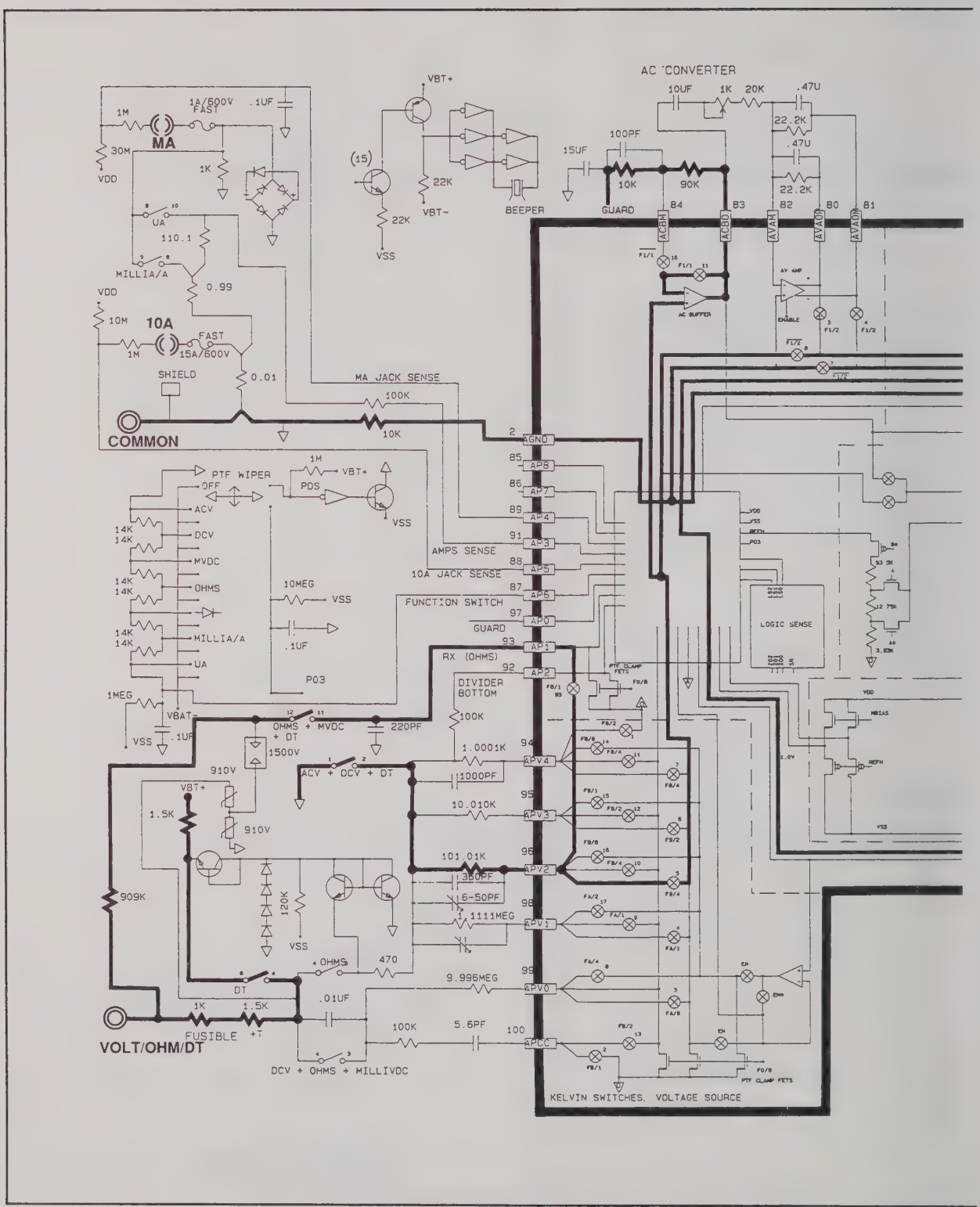
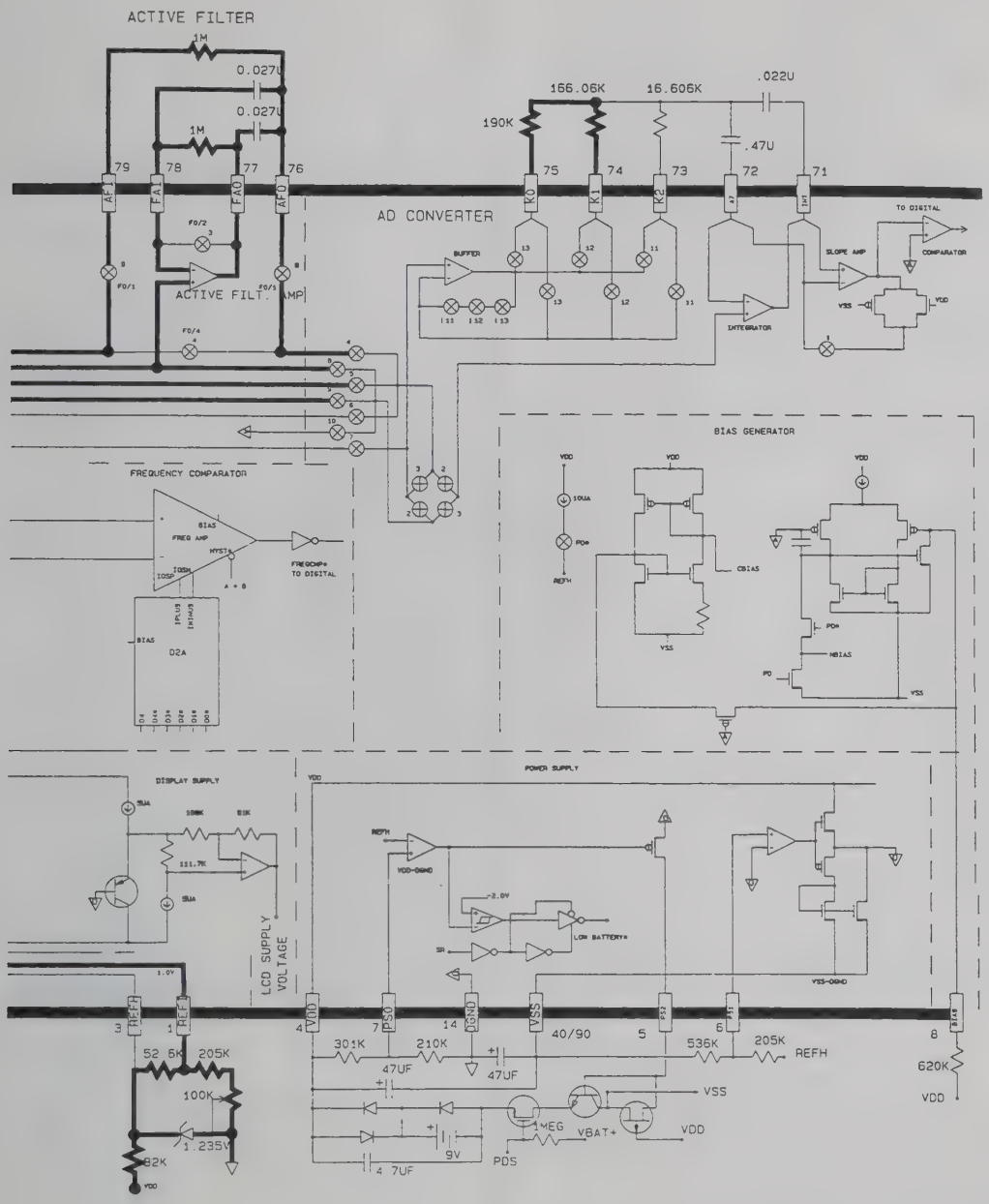


Figure 5-7. Diode Test/Lo Ohms Signal Flow


ACTIVE FILTER
1M
0.027U
0.027U
1M
79
78
77
76
AF1
AF0
AD CONVERTER
156.06K
16.606K
.022U
190K
.47U
75
74
73
72
71
K0
K1
K2
BUFFER
INTEGRATOR
SLOPE AMP
COMPARATOR
TO DIGITAL
VSS
VDD
FREQUENCY COMPARATOR
FREQ AMP
FREQCMP
TO DIGITAL
BIAS GENERATOR
10UA
PD
REFH
CBIAS
NBIAS
VSS
VDD
DISPLAY SUPPLY
POWER SUPPLY
LCD SUPPLY VOLTAGE
REFH
REFL
VDD
PSUB
DGND
VSS
BIAS
52.5K
205K
100K
1.235V
82K
301K
210K
47UF
47UF
40/90
536K
205K
REFH
620K
VSS
VDD
1MEG
VBAT+
9V
4.7UF
PDS

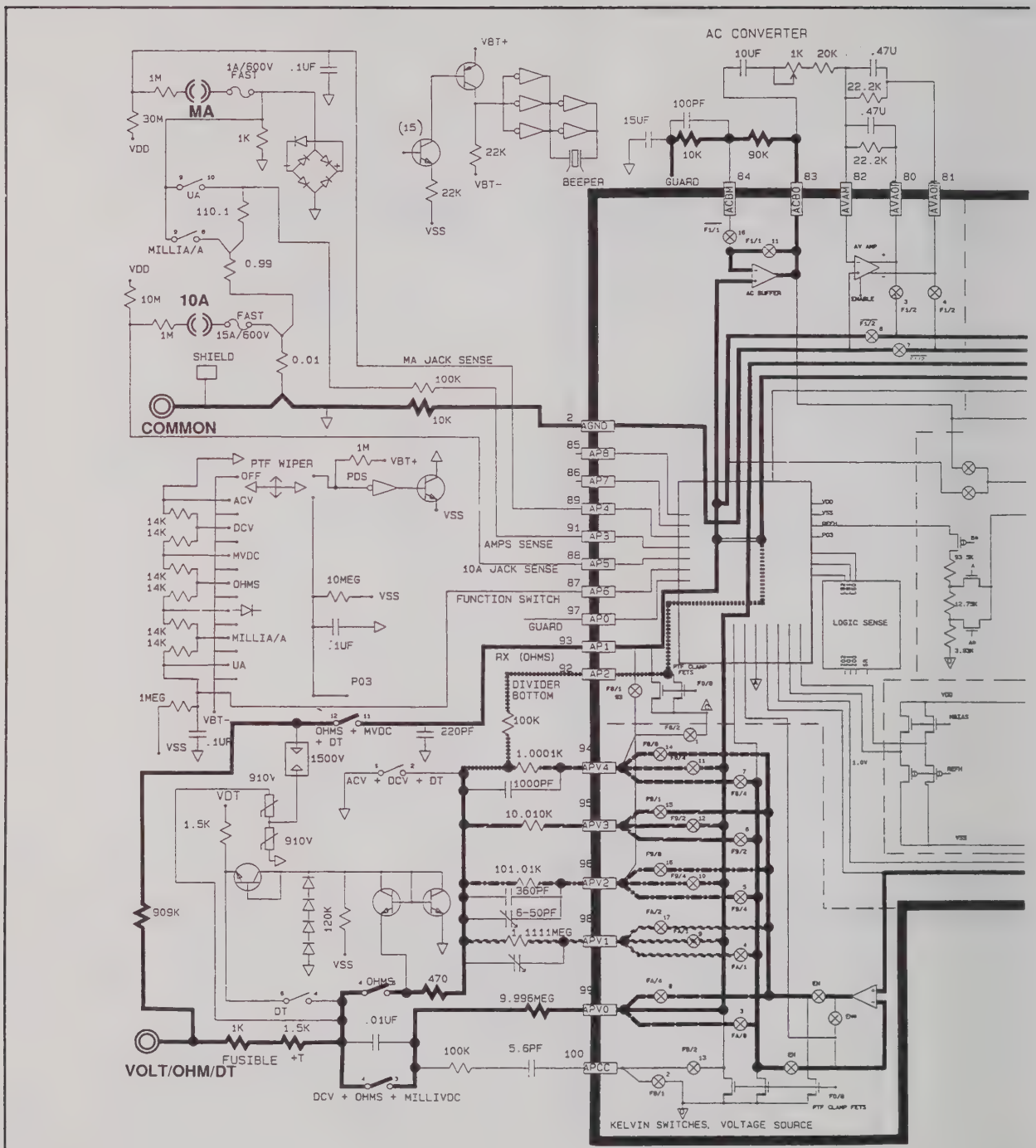
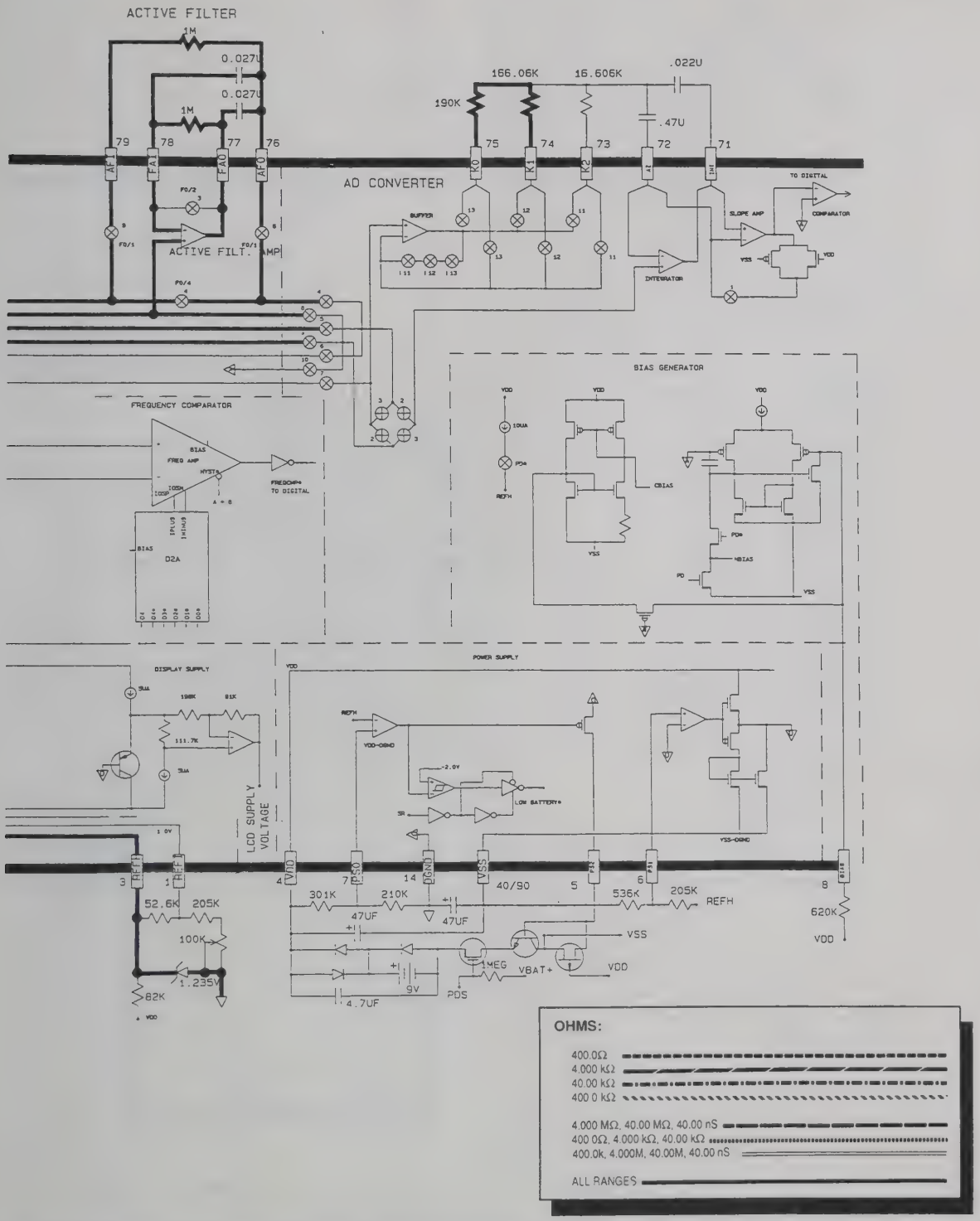


Figure 5-8. Ohms Signal Flow


ACTIVE FILTER
1M
0.027U
0.027U
1M
79
78
77
76
FA1
FA1
FA0
AF0
166.06K
16.606K
.022U
190K
.47U
75
74
73
72
71
AD CONVERTER
K0
K1
K2
INT
TO DIGITAL
COMPARATOR
SLOPE AMP
INTEGRATOR
VDD
VSS
BUFFER
ACTIVE FILT. AMP
FREQUENCY COMPARATOR
BIAS
FREQ AMP
HYST
FREQCMP4
TO DIGITAL
D2A
BIAS GENERATOR
10UA
PD
REFH
CBIAS
NBIAS
DISPLAY SUPPLY
5UA
190K
81K
111.7K
3UA
1.0V
LCD SUPPLY VOLTAGE
POWER SUPPLY
VDD-OSMD
-2.0V
LOW BATTERY
VSS-OSMD
REFH
REFL
VDD
VSS
DGND
BIAS
52.6K
205K
100K
1.235V
82K
301K
210K
47UF
47UF
40/90
536K
205K
620K
1MEG
VBAT+
9V
4.7UF
PDS
OHMS:
400.0Ω
4.000 kΩ
40.00 kΩ
400.0 kΩ
4.000 MΩ, 40.00 MΩ, 40.00 nS
400.0Ω, 4.000 kΩ, 40.00 kΩ
400.0k, 4.000M, 40.00M, 40.00 nS
ALL RANGES

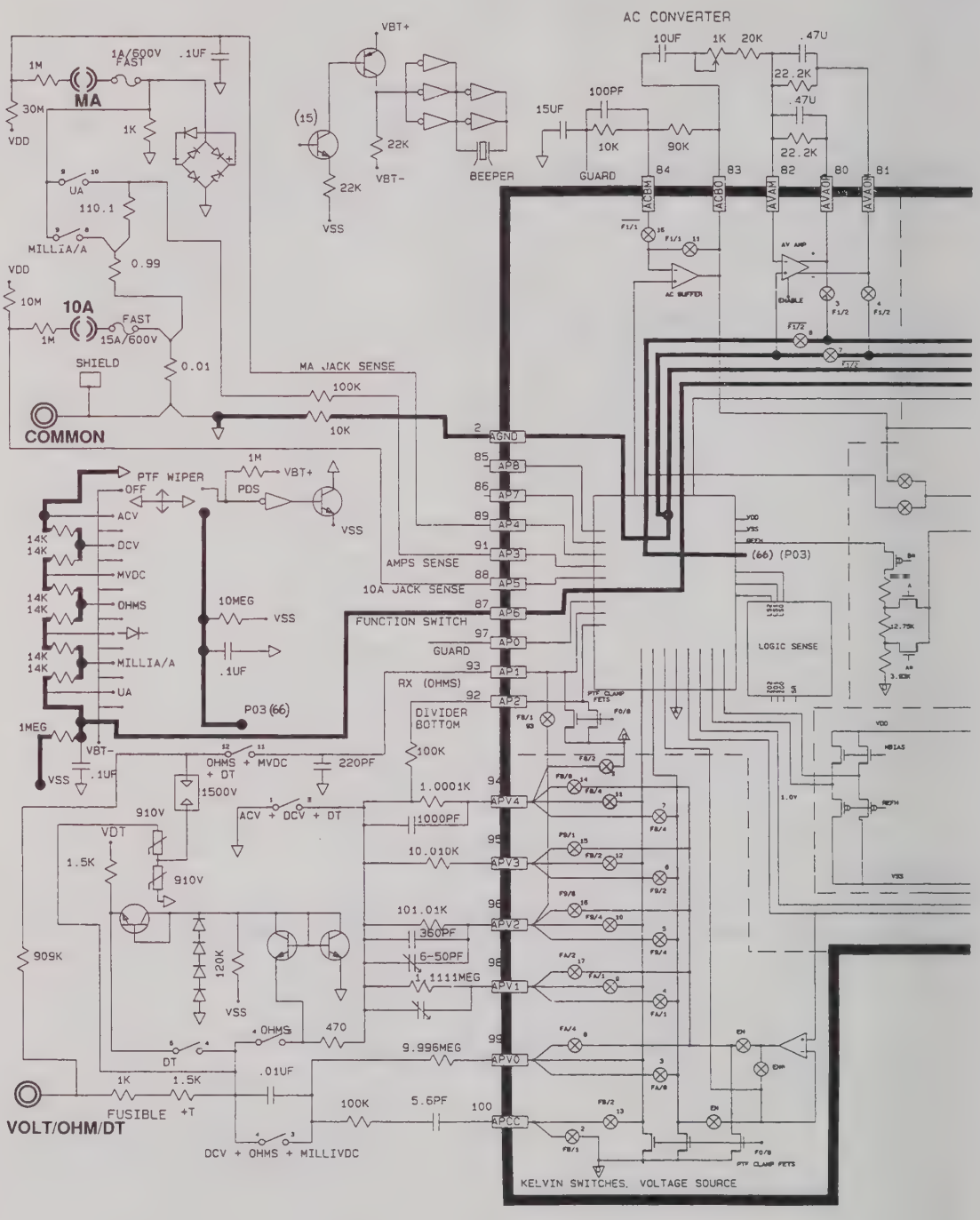
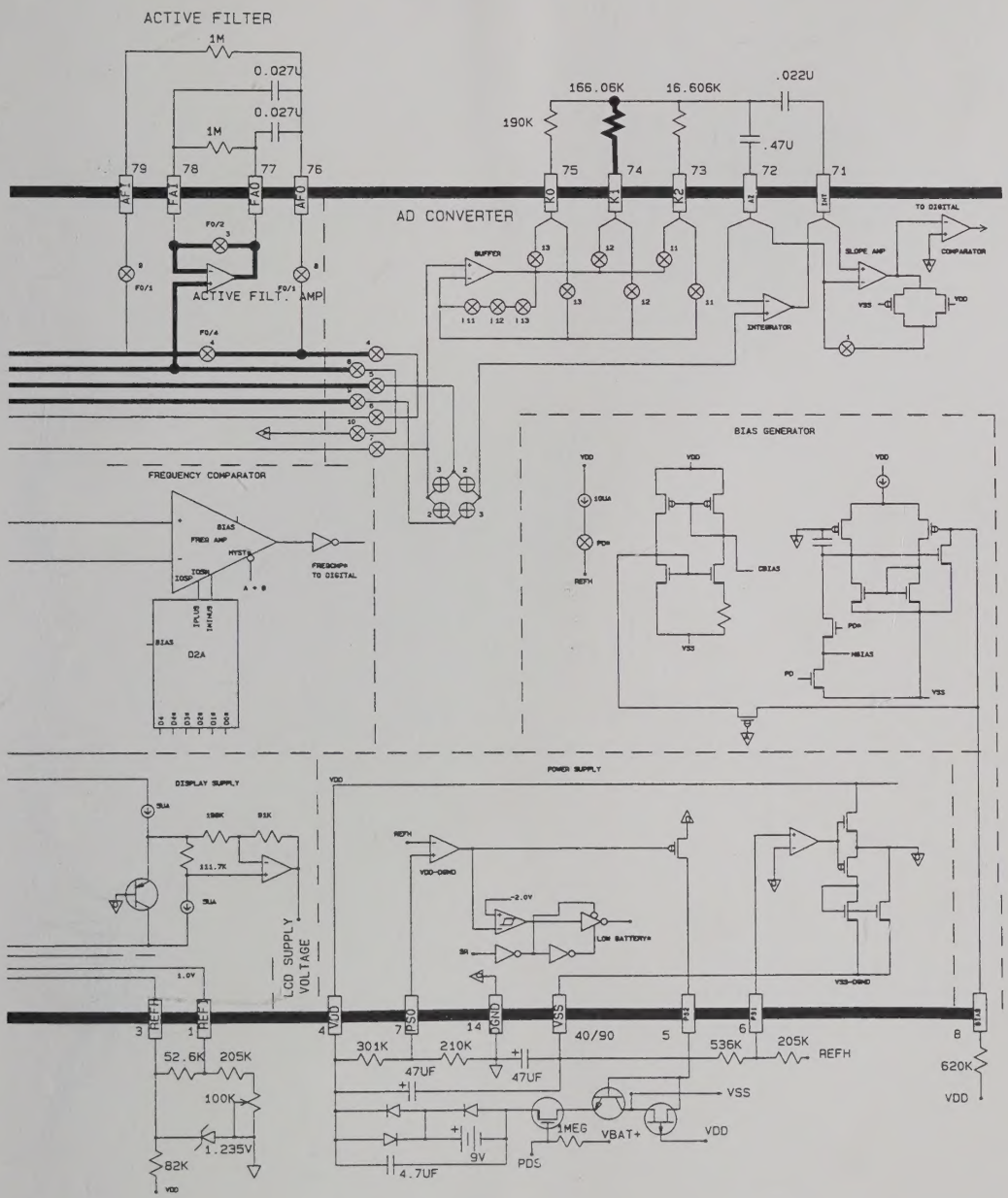
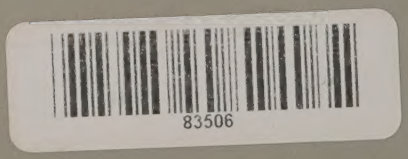


Figure 5-9. Function Switch Range/Ratio Test Signal Flow


ACTIVE FILTER
1M
0.027U
0.027U
1M
79
78
77
76
AF1
FA1
FA0
AF0
F0/2
F0/1
F0/1
ACTIVE FILT. AMP
F0/4
AD CONVERTER
166.06K
16.606K
.022U
190K
.47U
75
74
73
72
71
K0
K1
K2
INT
BUFFER
SLOPE AMP
TO DIGITAL
COMPARATOR
INTEGRATOR
VSS
VDD
FREQUENCY COMPARATOR
BIAS
FREQ AMP
HYSTR
IOSN
IOSP
FREQCMP0
TO DIGITAL
A + B
IPLUS
INTINP
BIAS
D2A
D14
D13
D12
D11
D10
BIAS GENERATOR
VDD
10UA
PD0
REFH
CBIAS
VSS
PD0
NBIAS
PD
VSS
DISPLAY SUPPLY
5UA
180K
81K
111.7K
5UA
1.0V
REFH
REFL
3
1
LCD SUPPLY VOLTAGE
POWER SUPPLY
VDD
REFH
VDD-DSMD
-2.0V
SR
LOW BATTERY*
VSS-DSMD
VDD
PDO
DGND
VSS
P32
P31
P33
4
7
14
40/90
5
6
8
52.6K
205K
100K
1.235V
82K
VDD
301K
210K
47UF
47UF
536K
205K
REFH
620K
VDD
VSS
1MEG
VBAT+
VDD
9V
PDS
4.7UF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